EFFECTS OF STRESS-RELEASE DISTURBANCE ON THE SHEAR BEHAVIOUR OF SIMULATED OFFSHORE OVERCONSOLIDATED CLAY SAMPLES

by

Chiu Kay Kwok

A thesis
presented to the University of Manitoba
in partial fulfillment of the
requirements for the degree of
Master of Science
in
Civil Engineering

Winnipeg, Manitoba, 1984

EFFECTS OF STRESS-RELEASE DISTURBANCE ON THE SHEAR BEHAVIOUR OF SIMULATED OFFSHORE OVERCONSOLIDATED CLAY SAMPLES

BY

CHIU KAY KWOK

A thesis submitted to the Faculty of Graduate Studies of
the University of Manitoba in partial fulfillment of the requirements
of the degree of

MASTER OF SCIENCE

ABSTRACT

This thesis investigates the effects of stress-release disturbance on the shear behaviour of simulated offshore overconsolidated clay samples. The test program was designed to search for laboratory procedures which can best recover the insitu strength of the clay. The study involved one-dimensional consolidation of remoulded illite followed by unloading, reconsolidation and undrained shearing. Careful handling of samples was emphasized so that mechanical disturbance could be minimized.

Eleven samples were consolidated one-dimensionally, first in cylinders from a slurry, and then in triaxial cells. The final overconsolidation ratio of the samples was 2.0. Nine of the samples were offloaded to simulate the sampling process, and then reconsolidated using the dwell period and the reconsolidation procedures as parameters for study. The undrained behaviour of these samples was then compared with that of two control samples which had not undergone stress-release disturbance and therefore represented the "insitu" behaviour.

During the period of total stress unloading from a mean principal stress of about 555kPa to 5kPa, the reductions in effective mean principal stress p' were only from 55kPa to 51.5kPa. During dwell periods after unloading, the further reductions in p' were 0-3.2kPa for samples subjected to 15-minute and 1-day periods, and 7.4-21.2kPa for 1-week-dwell samples. If identical reconsolidation procedures were used, the strengths of "samples" which had undergone undrained unloading were unaffected by the duration of the dwell period. Anistropic reconsolidation to "insitu"

stresses was successful in reproducing insitu shear strengths and A_f-values. Isotropic reconsolidation to 0.6 x σ'_{1c} was also successful in reproducing insitu strengths. A_f-values were however overestimated. Isotropic reconsolidation to 1.0 x σ'_{1c} overestimated both the insitu strengths and the A_f-values. All three reconsolidation procedures overestimated the ε_f-values and underestimated the E_{50} -values. The overconsolidated strength parameters determined were $c'=16kPa$ and $\phi'=18^{\circ}$.

ACKNOWLEDGEMENTS

The author wishes to express sincere thanks to his advisor, Dr. J. Graham for initiating this investigation, for his guidance and for invaluable advice throughout the whole project and during the preparation of this thesis.

Grateful thanks is also extended to the author's co-worker R. W. Ambrosie, for his helpful assistance, constructive suggestions and useful discussions throughout the whole project, for sharing the 7-day-per-week schedule and for making the experimental program less back-breaking through his physical abilities.

The assistance of the technical staff of the Civil Engineering Department, especially Mr. N. Piamsalee, is much appreciated.

Financial assistance throughout the author's postgraduate program in the form of support from the University of Manitoba Graduate Fellowship, Work Study Program, and NSERC grant A3712 are acknowleged.

The author is deeply indebted to his parents and his wife Joann for their constant support and encouragement during the course of his graduate studies, and for Joann's excellent effort in typing part of this thesis.

The author also wishes to acknowledge the graduate students of the Geotechnical group, Mr. R. Kwok in particular, for their making his Master program enjoyable and rewarding at times.

TABLE OF CONTENTS

LIST OF SYMBOLS

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

A_f - value of A at failure

c' - effective cohesion

c_v - coefficient of consolidation

CAU - strain-controlled, consolidated anisotropically undrained compression test

CK_oU - strain-controlled, consolidated-anisotropically (following K_o line) undrained compression test

CIU - strain-controlled, consolidated isotropically undrained compression test

e - voids ratio

E_{50} - elastic modulus to 50 percent of yield stress in undrained shear

G_{eq}, K_{eq} shear and bulk moduli dependent on stress path direction

K - σ_3'/σ_1'

K_o - coefficient of earth pressure at-rest

LSSV - length of stress vector

m_v - coefficient of volume change

OCR - overconsolidation ratio

p' - effective mean principal stress = $(\sigma_1' + \sigma_2' + \sigma_3')/3$

q - deviator stress = $(\sigma_1 - \sigma_3)$

q_{max} - maximum deviator stress

q_y - deviator stress at yield

s_u - undrained strength = $q_{max}/2$

u - porewater pressure

U_R - residual porewater pressure

U_{Ri} - initial residual porewater pressure

v - volumetric strain in triaxial compression test

v_c - v at the end of triaxial consolidation to σ'_{1c}, σ'_{3c}

V - specific volume = $1 + e$

w - moisture content

w_L - liquid limit

W - strain energy absorbed per unit volume

$\Delta\varepsilon_1, \Delta\varepsilon_3$ - change of ε_1 and ε_3 between consecutive load increments

$\Delta\varepsilon_{1rc}, \Delta\varepsilon_{3rc}$ - ε_1 and ε_3 during reconsolidation

$\Delta p'$ - change in effective mean principal stress

Δu - change in porewater pressure

Δv_{rc} - v during reconsolidation

$\varepsilon_1, \varepsilon_3$ - major and minor principal strains (ie. axial and radial strains in triaxial compression test)

ε - shear strain = $2(\varepsilon_1 - \varepsilon_3)/3$

$\varepsilon_{1c}, \varepsilon_{3c}$ - ε_1 and ε_3 at the end of triaxial consolidation to $\sigma'_{1c}, \sigma'_{3c}$

$\varepsilon_{\rho e}$ - axial strain at the end of relaxation test

$\varepsilon_{\rho s}$ - axial strain at the start of relaxation test

γ_{sat} - unit weight of saturated soil

γ_{sub} - unit weight of submerged soil

γ_w - unit weight of water

κ_1 - slope of reload line in $\ln(p')$, V space during triaxial consolidation

κ_2 - slope of unload line in $\ln(p')$, V space during triaxial consolidation

λ_1 - slope of normally consolidated line in $\ln(\sigma_v)$, V space during cylinder consolidation

λ_2 - slope of normally consolidated line in $\ln(p')$, V space during triaxial consolidation

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

σ'_y - effective average yield stress based on different yield criteria

$\sigma'_1,\sigma'_3{}'$ - major and minor effective principal stresses

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

σ'_{cyl} - effective vertical stress applied during cylinder consolidation

σ_v - vertical pressure

σ'_v - effective vertical pressure

σ'_{vc} - effective vertical preconsolidation pressure

ϕ' - effective angle of shearing resistance

LIST OF TABLES

LIST OF FIGURES

FIGURE PAGE

Chapter I

INTRODUCTION

1.1 GENERAL

All civil engineering works apply loads to underlying strata. The fundamental theories of soil mechanics, site investigation practices, analysis and design in geotechnical engineering have all been relatively well developed. However, because of the nature of the work, most of the research efforts on all these aspects and the comparisons with field performance have been associated with constructions onshore. Until recent years, structures offshore have received very little attention as far as geotechnical engineering is concerned. Exceptions included the civil engineering design of shallow water structures such as wharfs, docks, dams and breakwaters. In the past two decades, the increasing demand for energy resources and the unstable political situation in the oil-rich Middle-East have pushed hydrocarbon recovery into offshore areas in many parts of the world. This has caused more attention to be placed on offshore geotechnical engineering, for both the evaluation of offshore soil profiles and behaviour, and for appropriate design and construction practice.

There are two kinds of seabed structures commonly used as drilling platforms in offshore hydrocarbon recovery, namely gravity structures and piled structures. A gravity structure consists of massive concrete units resting on the seabed. It relies on its large mass to provide the stability to resist loads imposed for example by wind, currents and waves. On the other hand, a piled structure consists of steel members connected in a tower configuration, with piles penetrating underwater strata to provide stability. In most cases (especially in deep water), piled structures are more economical compared with gravity structures.

As hydrocarbon recovery moves into deeper water in many parts of the world, structural loads for the piles increase (Semple et al(1982)). Larger and longer piles are being used. These piles frequently penetrate into stiff clays that appear to be normally consolidated. (At the time of writing, water depths commonly approach 200m, piles may be 2.5m diameter, and penetrate 75m into stiff clay or sand.) Design of piles requires: (1) a knowledge of the strength of the clay, (2) an understanding of the behaviour of long and relatively compressible piles in stiff clay, and (3) a collection of case studies regarding the design and the field performances of piled structures.

This thesis deals with the first of these three requirements, namely the problem of finding the strength of the clay in the seabed. Both insitu testing and laboratory testing are used in practice to measure the strength of the clay. Cone penetrometer testing is now a standard part of many site investigations, while a range of other devices, such as the pressuremeter and the remote vane are applied occassionally. An advantage of insitu testing is that it usually provides continous records of the soil variability. However there is ongoing discussion among researchers regarding the conversion of the measured results to commonly used design parameters such as the cohesion c[1] and the friction angle ϕ. A complete offshore geotechnical investigation therefore commonly comprises both insitu testing and sampling for laboratory testing. Laboratory testing commonly consists of on-board testing of samples for a preliminary evaluation

---

[1] symbols are defined in the LIST OF SYMBOLS

of the data, and further testing in an onshore laboratory for detailed analysis (De Ruiter and Richards(1983)).

This research project deals with problems associated with sample disturbance. Equipment which aims at reducing mechanical disturbance during collection of offshore samples is quite well developed (De Ruiter and Richards(1983)). Examples are (1) the hydraulically activated motion compensator to overcome problems associated with heaving of the drilling vessel in seawaves, and (2) seabed mounted drill string control units (Fugro's "Seaclam" and McClelland's "Stingray" for example) which serve to increase reaction and to provide both vertical and horizontal stability of the drilling equipment during operation. The aspect of mechanical disturbance will not be studied in this investigation. The thesis deals specifically with the other aspect of sampling disturbance, namely process disturbance due to stress release. Seabed clays can be under high effective stresses and high porewater pressures depending on the soil depth and the water depth. Sampling causes release of the total stress which leads to the generation of high negative porewater pressure and swelling of the samples. The degree of stress-release disturbance experienced by the samples is complicated by the duration of the dwell period between sampling and testing in the laboratory.

Consolidated undrained shear tests are usually performed to determine the strengths of clay samples. However even for perfect samples which have undergone no mechanical disturbance during sampling, stress-release disturbance causes the strengths measured from "samples"[2] to be unrepresentative of the "insitu soils".[3] The present study is designed to gain

---

[2] "samples" in this thesis refers to those soil specimens which have undergone process disturbance during sampling.

[3] "insitu soils" in this thesis refers to the soils in the ground, to which no manmade disturbance has been introduced.

more insight into the behaviour of offshore samples under conditions of stress release, and to search for laboratory procedures which can best recover the insitu strength of the clay.

1.2 OBJECTIVES

As mentioned previously, the main purpose of the present study is to recover in the laboratory the insitu strengths of offshore clays which have undergone stress release after sampling. In addition to this, the other specific aims of this investigation are as follows:

1. to continue the development in the University of Manitoba of techniques for preparation and testing of one-dimensionally consolidated remoulded clay samples.
2. to measure the failure envelope and Critical State parameters of remoulded illitic clay from Illinois (Grundite used by Wu et al(1983)).
3. to investigate other traditional parameters such as undrained shear strength, porewater pressure parameters, elastic moduli, relative stiffness and strain rate parameters for the remoulded illitic clay.

The laboratory testing program consisted of eleven large diameter (76mm) triaxial tests on overconsolidated clay. (Another eleven samples on normally consolidated clay were included in a parallel program conducted by Ambrosie(1984).) Standard classification tests on the remoulded illitic clay were also carried out.

A review of sample disturbance associated with stress release will be presented in Chapter 2, before proceeding to the design of the testing program in Chapter 3. Following the sample preparation and test procedures in Chapter 4, the results obtained from consolidation and undrained shear tests are presented in Chapters 5 and 6. Discussion of the test results and conclusions are presented in Chapters 7 and 8 respectively. These will be followed by tables, figures and appendicies.

Chapter II

A REVIEW OF SAMPLE DISTURBANCE ASSOCIATED WITH STRESS RELEASE

2.1 INTRODUCTION

In recent years, the ever increasing demand for energy resources has pushed the petroleum industry into offshore recovery. Regardless of the type of production platforms selected, geotechnical investigations of the seabed sediments are required. Offshore site investigations originated in the shallow and relatively calm waters of the Gulf of Mexico. The supporting piles for platforms could therefore be designed on the basis of relatively simple site investigations. As hydrocarbon recovery moves into more difficult soil profiles, deeper waters and adverse environments in other offshore areas of the world, (e.g. the North Sea and the Beaufort Sea), larger and longer piles are being used (Gibson and Dowse(1981), Semple et al(1982)). Complex and precise investigations are now required for the design of safer and more economical foundations.

The insitu shear strengths of clays are commonly measured by testing "undisturbed" samples collected from the seabed. These so called "undisturbed" samples have however undergone two categories of disturbance, namely mechanical disturbance and process disturbance. Mechanical disturbance is associated with pushing, rotating and extracting the sample tube during sampling. Process disturbance on the other hand, is associated with the release of the effective and porewater stresses experienced by the sample while it was still in the seabed. The research presented in this thesis has been designed specifically to investigate the influence of process disturbance on the quality of samples, leaving out those effects associated with mechanical disturbance.

This chapter summarizes works by various investigators on the area of sample disturbance due to stress release. Since only a limited amount of research has been directed specifically at process disturbance of offshore clay, similar research on onshore clay will also be included in the discussion.

2.2 GENERAL REVIEW

Skempton and Sowa (1963) showed that the water content of a saturated clay was not altered by good quality sampling. However the clay was subjected to changes in stress state even if there was no mechanical disturbance. They further suggested that the common belief that the mean principal effective stress in the sample was held constant by the generation of negative porewater pressure was not true in most cases, since few natural clays were perfectly elastic.

Ladd and Lambe (1963) suggested that even without mechanical disturbance during sampling, insitu stresses were released and the effective stress of the sample decreased. The mean principal effective stress left in the extracted sample, termed the "residual effective stress", σ'_{pp} , for a saturated clay became as follows:

$$\sigma'_{pp} = \sigma'_{v} [K_o + (1 - K_o)A_p] \qquad (2.1)$$

in which σ'_v is the insitu effective vertical stress, K_o is the coefficient of earth pressure at-rest, and A_p is the Skempton's porewater pressure coefficient for "perfect sampling". ("Perfect sample" here refers to sampling without mechanical disturbance.) They further suggested that the value of K_o was about 0.5 for normally consolidated clay and that A_p ranged from -0.1 to +0.3. The residual mean principal effective stress therefore became about $0.55\sigma'_v$ which was less than the insitu mean effective stress of approximately $0.67\sigma'_v$ by about 20%.

Okumura (1971) however argued that in actual sampling, the condition of full saturation was not always satisfied even in the case of soils below the watertable. If the porewater contained dissolved air which would come out of solution due to decreases in the porewater pressure, the residual effective stress, σ'_p, of the perfect unsaturated sample became:

$$\sigma'_p = \sigma'_{pp} - \frac{V_{ap} - V_{ao}}{m_s V_o} \quad \text{, where} \qquad (2.2a)$$

$$\frac{V_{ao} + V_d}{V_{ap} + V_d}\left(U_o + \frac{2q}{r_o} - U_d\right) - \frac{2q}{r_o}\left(\frac{V_{ao}}{V_{ap}}\right)^{\frac{1}{3}} + \sigma'_p + U_d = 0 \qquad (2.2b)$$

in which m_s is the coefficient of volume expansibility, V_o is the insitu volume of the sample, V_{ao} is the insitu volume of air, V_{ap} is the air volume after perfect sampling, V_d is the equivalent volume of dissolved air, U_o is the initial porewater pressure, U_d is the saturated vapour pressure of water, q is the surface tension and r_o is the insitu radius of the air bubble. Since the air volume after perfect sampling was generally larger than the insitu air volume, the residual effective stress was therefore less than that of full saturation.

Dealing with Norwegian quick clays, Schjetne (1971) suggested that when the clay was in a sample tube, the remoulded zone along the inside wall of the tube had a surplus of water which allowed the undisturbed material to swell. Even if the sample was mechanically undisturbed, it could become severely disturbed due to the swelling associated with stress release.

Procter (1976) considered offshore samples to be "undisturbed" when they were not only mechanically undamaged but were also in a condition that the insitu effective stresses and the degree of saturation were unaltered. Using North Sea sampling as an example, he further suggested that since the samples of stiff clay being recovered were small and were under high suction (negative porewater pressure), loss of effective stress had to occur. This was further complicated by the release of dissolved gases which would come out of solution from the pore fluid as the stress was released. He concluded that laboratory testing without taking stress release into account would therefore lead to underestimation of the shear strength.

In summary, it is clear that stress release causes sample disturbance due to swelling. The assumption that the effective stresses remain constant before and after sampling is not supported by most of the researchers mentioned above. The assumption is only true (even neglecting mechanical disturbance) if the following conditions are met: (a) the soils are completely saturated, (b) the soils are perfectly elastic, (c) the absorption of free water during sampling is negligible, and (d) the soil water is capable of carrying all of the tension stress caused by the release of the insitu stresses without vaporizing. These conditions can hardly be fulfilled by the sampling procedures commonly employed for most natural clays. A certain degree of sample disturbance due to stress release (loss of suction) is therefore inevitable.

2.3 DETAILED REVIEW OF PUBLISHED TESTING PROGRAMS

Knowing that stress release causes sample disturbance, many researchers have conducted tests to determine quantitatively the effects of stress release on the geotechnical properties of different clays. Parameters being investigated were commonly related to undrained shear and consolidation behaviour. Frequent parameters examined in shear tests included undrained strength, failure strain, Young's modulus and Skempton's porewater coefficient A. Frequent examined consolidation properties included preconsolidation pressure, compressibility (m_v), coefficient of consolidation (c_v) and permeability (k). Due to time limitation, the research presented in this thesis deals only with the parameters related to undrained shearing. This section gives an overview of the tests performed and the conclusions drawn by different researchers on the topic of stress release on undrained shear properties of different clays.

Skempton and Sowa (1963) tested remoulded Weald clay from Dorking, Surrey, England. The combined silt and clay fractions consisted predominantly of fine quartz and illite, with small proportions of kaolin and chlorite. To prepare samples, a quantity of clay was mixed with water to a moisture content of 33.5% (0.73 x w_L). Some of the clay was then packed into a brass tube of 38 mm internal diameter to form a triaxial sample 84 mm long. Two specimens were then consolidated anisotropically (K_o) in triaxial cells at each of four different effective lateral pressures ranging from 124 to 690kPa. The strength "in the ground" was measured by undrained shearing a sample immediately after triaxial consolidation. To simulate the sampling process, the second specimen of each pair was unloaded undrained. The unloading procedure involved reducing the shear stress to zero (ie. the isotropic stress condition equalled the cell pressure at the end of triaxial consolidation). The strength of the "sample" was then measured by undrained shearing.

During unloading, the strain was about 1% axial extension. Although the subsequent stress paths during shear were different, the undrained shear strength and the effective stresses at failure of a "sample" were virtually equal to those of "in the ground" for all four consolidation pressures. They therefore concluded that if two identical specimens of saturated clay were subjected to different changes in total stress without alteration in moisture content, and if the strains due to stress changes caused little alteration in micro-structure, the undrained strengths of the two specimens would be identical.

Adams and Radhakrishna (1970) tested normally consolidated insensitive glacial lake clay from St. Clair River in Southern Ontario. Samples for laboratory testing were trimmed from block samples taken from the field. Initial measurements of the residual suction pressure of the block samples were made using a fine ceramic stone in the triaxial cell base. After K_o consolidation to insitu stresses, undrained shear was conducted to measure the "insitu" strength. To simulate a sample having no loss in suction (perfect sampling), the deviator stress of a second sample was removed undrained after K_o consolidation. This was followed by undrained shearing. After unloading from the K_o or insitu stress condition, a third sample was allowed to return to its initial residual suction pressure with drainage permitted. This simulated an actual sample having lost a portion of its suction. Again, an undrained shear test was performed to determine the strength. The test showed that the strengths for the "insitu" sample and the "perfect" sample (ie. no loss in suction) were identical. Specimens allowed to swell and lose suction showed a significant loss in strength.

Schjetne (1971) used a hypodermic needle piezometer placed inside the piston of a NGI 95mm thin-walled fixed piston sampler. This arrangement was able to measure the porewater pressure generated within a Norwegian quick clay sample from the moment of cutting in the ground, during lifting of the sampler and the sampling tube, during transportation of the tube to the laboratory and until the clay was extruded for testing. He found that the stress changes in the clay during sampling were more complex than the common belief that a total stress release was compensated by the negative porewater pressure built up. At 30cm below the piston, the porewater pressure due to the pressing down of the sampler was 1.5-2 times the original porewater pressure, even as long as 40 minutes after the sampler had reached the desired depth. Rather than total stress release during the cutting operation, high positive porewater pressures were generated. No total stress release was observed until the sample tube was removed from the sampler. The negative porewater pressure measured at this stage was about 20% of the effective overburden pressure, and later on the same day, it dropped to zero. This indicated that the clay was allowed to swell due to free water in the remoulded material along the tube walls. The swelling was a time dependent phenomenon, causing the negative porewater pressure to decrease and the disturbance to increase with time.

Kirkpatrick(1982) studied the stress release effect on undrained shear strength for both normally consolidated and overconsolidated kaolin and illite. Samples were prepared by one-dimensionally consolidating a slurry (moisture content=1.5 x w_L) in a 254mm diameter oedometer. This paragraph describes the procedures used by Kirkpatrick and the results he obtained from normally consolidated clay. A final pressure of 552kPa was applied to simulate the high insitu stress states in the seabed. The procedures of sampling were modelled by closing the end drains (undrained) of the oedometer and rapidly reducing the pressure to zero. The oedometer apparatus was then quickly stripped and the block of clay removed. The total process of unloading and stripping took about 5 minutes. Material produced by this drained loading followed by undrained unloading was referred to as "samples". After removal from the oedometer, the block was sealed, wrapped and stored. At various intervals dictated by the test program, test specimens were cut using thin-walled tubes from these blocks of clay. "Insitu" samples were prepared by first consolidating a slurry in an oedometer to 276kPa (half of that employed for "samples"). Specimens were then cut and set up in triaxial cells, consolidated anistropically (K_o) to a range of "insitu" stresses, and sheared undrained to determine the "insitu" shear strengths. The final vertical consolidation stresses ranged between 400kPa and 800kPa. The influence of sample age on shear strength was also studied. Sample age was defined as the time elapsed between unloading of the block and the time of testing. Ages ranged from a few hours to 50 days. The samples were then subjected to undrained shearing. The undrained shear strengths of "samples" (c_{us}) for both kaolin and illite were considerably lower than their respective "insitu" undrained strengths (c_{ui}). The ratios of c_{us}/c_{ui} for both kaolin and illite showed a gradual decrease with sample age after an initial drop to 62% for illite and 46% for kaolin within 5 hours of unloading. The ratio became approximately constant at about 48% for illite and 32% for kaolin after a sample age of 50 days, (that is, the additional loss of c_{us}/c_{ui} from the age of 5 hours to 50 days was about 14% for both clays.) The negative porewater pressure retained by the "sample" was termed the "residual porewater pressure U_R". The value immediately after unloading was termed "initial porewater pressure U_{Ri}". Estimations of U_R for the "samples" were performed in the triaxial cell prior to shearing. With the drains closed, the cell pressure was increased in stages while the porewater pressure was monitored. Plotting porewater pressure on the y-axis and cell pressure on the x-axis, the straight portion of the line was extrapolated, and the y-intercept was termed the residual porewater pressure (Bishop and Henkel(1962)). Illite and kaolin both showed the trend of dropping in the

U_R/U_{Ri} ratio with sample age as observed in the c_{us}/c_{ui} ratio. The failure strain (ε_f) of "samples" were about 2.5 to 3 times higher than those for "insitu" values for kaolin and 3 to 4 times higher for illite. The secant modulus values (E_s) for both kaolin and illite "samples" dropped progressively with age, with the 50-day values approximately half of those at 5 hours. The porewater coefficient (A_f) for both kaolin and illite also showed a gradual decrease in value with sample age. The A_f values dropped from 0.32 to 0.07 and 0.47 to 0.08 for kaolin and illite respectively at sample ages from 5 hours to 50 days.

Kirkpatrick also dealt with overconsolidated kaolin and illite. The overconsolidation ratio was 2 for kaolin and 2.67 for illite. The materials and methods for preparing blocks of overconsolidated clay were the same as those for normally consolidated clay described in the previous paragraph. The K_o values were 0.847 for kaolin and 0.94 for illite. (When normally consolidated, K_o=0.56 for kaolin and 0.68 for illite.) To produce "insitu" overconsolidated soil, a slurry was consolidated to form a normally consolidated cake. Specimens were then cut from these cakes and were consolidated anisotropically in triaxiall cells to 552kPa. They were then unloaded following appropriate effective stress paths to achieve the required axial stress and stress ratios. Final stresses were left on for 4 days before undrained shearing. "Samples" of overconsolidated clay were prepared by consolidating a slurry in an oedometer to 552kPa, then offloading to stresses that created the desired overconsolidation ratio. The final pressure was kept on for 4 days before the oedometer was stripped as described previously to simulate the sampling (stress release) procedure. The block was then waxed, sealed and stored as before. Samples were cut from these blocks at various ages and tested to measure the undrained strength. Comparing the strengths of the "samples" and the "insitu" soil, the ratio of c_{us}/c_{ui} showed the characteristic drop with age as observed previously. These ratios however were higher than those associated with the normally consolidated soils. (The ratio dropped from 72% to 53% for illite and from 63% to 41% for kaolin at ages from 5 hours to 50 days.) The ratios of U_R/U_{Ri} again dropped gradually with age. The proportional loss in both the residual porewater pressure and strength was smaller for the overconsolidated soil than for the normally consolidated soil. Kirkpatrick suggested that the reason could be due either to different behaviour of overconsolidated and normally consolidated soil, or simply that the stress changes in the case of overconsolidated soils were smaller than those for the normally consolidated soil.

2.4 METHODS OF RECOVERING "INSITU" STRENGTHS

It is now clear that the undrained shear strengths obtained from collected samples are not representative of the insitu values. Even for samples which have not undergone mechanical disturbance, the swelling which causes reduction in effective stress still leads to considerable loss of strength. This section outlines previous work by various researchers to recover the "insitu" shear strengths of clays. Two commonly used approaches were: (a) correct the laboratory obtained strengths using a multiplication factor, or (b) employ appropriate laboratory reconsolidation procedures.

2.4.1 Multiplication Factor

The insitu shear strength can in principle be estimated by applying an empirical multiplication factor to the laboratory shear strength. Since it is reasonable to relate the values of the correction factors to the degree of disturbance that samples have undergone, it is necessary to define the degree of disturbance quantitatively. Several "degrees of disturbance" have been proposed as follows:

1. Ladd and Lambe (1963) .... $D = \sigma'_p/\sigma'_s$

   where σ'_s is the residual effective stress of a taken sample and σ'_p is that of the perfect sample.
2. Noorany and Seed (1965) .... $R = \sigma'_p - \sigma'_s$
3. Davis and Poulos (1966) .... $D = \Delta e/\Delta e_{max}$

   where Δe is the difference between the insitu void ratio and that of the sample taken at the preconsolidation pressure. Δe_{max} is the void ratio between the insitu and that of the completely remoulded sample.
4. Okumura (1971) .... $D = 1 - \frac{\sigma'_s}{\sigma'_p}$

Other definitions for the "degree of disturbance" may be used. For example, the ratio of

$$\frac{s_{up} - s_{ud}}{s_{up} - s_{ur}}$$

where s_{up} is the perfectly undisturbed strength, s_{ud} is the disturbed sample strength, and s_{ur} is the fully remoulded strength. The researchers proposed that the strength correction factor could be evaluated directly after determining the degree of disturbance using expressions they suggested. Most of the expressions are complex and largely conceptual since they imply knowledge of "perfect" strength. They mostly relate to the effects of mechanical disturbance and will not be reviewed here. Details can be found in the original literature.

2.4.2 Reconsolidation Procedures

Many investigators have suggested that the "insitu" strengths of clays could be successfully recovered in the laboratory by employing appropriate procedures of reconsolidation before undrained shearing. This section briefly outlines some of the procedures they suggested.

Isotropic consolidation to the insitu effective vertical stress is commonly adopted by most commercial laboratories as the reconsolidation procedure. However it is generally believed to result in overestimating the strength (Casagrande and Rutledge(1947), Schmertmann(1956), Bishop and Bjerrum(1960), Ladd and Lambe(1963)). Other suggestions have included isotropic consolidation from half to three-quaters of the insitu vertical stress (Lowe(1967), Raymond et al(1971)), and K_o consolidation to the insitu stresses (Davis and Poulus(1967), Bjerrum(1973)). These proposals however could only be suggestions because the actual "insitu" strengths that were intended to be recovered were unknown. Many investigators compared the laboratory results obtained by using different reconsolidation procedures with those obtained from insitu tests such as the field vane. The interpretation of insitu test results however require empirical corrections. These corrections are generally produced by correlating with the strengths obtained from laboratory testing of high quality "undisturbed" samples. In other words, the strengths obtained from insitu tests are themselves "incorrect" originally since the "undisturbed" samples have undergone disturbance. It is the author's view that judging the success of reconsolidation procedures by comparing results with those obtained by insitu tests is therefore not justified.

Since the "insitu" behaviour of the clay was precisely known in the study by Kirkpatrick(1982), evaluation of the reliability of reconsolidation procedures could be made. For normally consolidated kaolin and illite, four procedures were used. They can be outlined as follows. (a) K_o (progressive) reconsolidation to insitu stresses. (b) K_o (2-step) reconsolidation to insitu stresses. (In this method the total isotropic component was applied in one stage. After the porewater pressure generated from this step had dissipated, the total deviatoric part of the insitu stress was applied again in one step.) (c) Isotropic reconsolidation with the cell pressure equal to the vertical consolidation pressure which the "sample" had experienced (σ'_{1c}). (d) Isotropic reconsolidation with the cell pressure equal to the absolute value of the initial porewater pressure (U_{Ri}).

The following conclusions were drawn from the above tests:

1. Both methods (a) and (b) above were successful in reproducing the "insitu" strength and A_f values. The failure strains were however larger than the "insitu" values.
2. Comparing results obtained by methods (a) and (b), it was suggested that method (b) was satisfactory and was preferred due to its shorter required time.
3. Method (c) led to overestimation of the "insitu" strength, failure strains and A_f values.
4. Method (d) led to underestimation of the "insitu" strength by about 16%. The A_f values and the failure strains were however greatly overestimated.
5. If the moisture contents of the samples were unaltered, age had little or no effect on consolidated undrained behaviour up to sample ages of one month.

For overconsolidated kaolin and illite, three reconsolidation procedures were used. They can be outlined as follows. (a) K_o (2-step) reconsolidation to "insitu" stresses. (b) Isotropic reconsolidation with $\sigma_3=\sigma'_{1c}$ "insitu". (c) Isotropic reconsolidation with $\sigma_3=|U_{Ri}|$.

Conclusions for overconsolidated kaolin and illite were similar to those drawn for normally consolidated soils. Reconsolidating "samples" anisotropically to "insitu" stresses was considered satisfactory in reproducing "insitu" strengths, although the secant modulus values were underestimated by the "samples". These conclusions were considered valid for overconsolidation ratios giving K_o values close to unity, that is overconsolidation ratios from 2.0 to 2.5 (Kirkpatrick(1982)).

2.5 SUMMARY

In summary, stress release during sampling has been known to have caused disturbance to clay samples. Although much research has been conducted to determine quantitatively the strength loss as compared to the "insitu" values, the methods used were not convincing until recent work by Kirkpatrick(1982). However in the author's view, this study still possessed some inadequacies in laboratory procedures.

The research presented in this thesis investigates the strength loss problem in detail. Some laboratory procedures employed were changed from those adopted by Kirkpatrick(1982) to better model the stress releases that occur in field sampling. Chapter 3 provides the reasons leading to the selection of parameters for study and an overview of the testing program that has been performed.

Chapter III

DESIGN OF TESTING PROGRAM

3.1 INTRODUCTION

The objective of this investigation was to study the effect of sample disturbance due to stress release in offshore clay, neglecting those effects associated with mechanical sampling disturbance. The degree of offloading disturbance is complicated by (a) the high porewater pressure experienced while the clay was still in the seabed, and (b) the duration of the time lapse between sampling in the field and testing in the laboratory (dwell period). The aim of this investigation was to develop a procedure for recovering in the laboratory the "insitu" undrained shear strength of seabed clay. In principle, such a procedure involves sampling (perfect sampling without mechanical disturbance), storage, reconsolidation and undrained shearing. This chapter provides the background leading to the selection of the parameters being studied and an overview of the test program that has been performed.

3.2 GENERAL

All the test samples in this project were prepared from remoulded illitic clay from Grundy County, Illinois. The testing of remoulded soils is common in many research laboratories. The advantage of using remoulded clay rather than natural clay is that after remoulding, the clay does not possess any "memory" of its past experience throughout geological time. In other words, the clay obtained is normally consolidated, unless specific action is taken to produce artificially overconsolidated samples. Since all samples are subjected to identical treatment except for the difference in stress release histories between "insitu soil" and "samples" as defined in Chapter 2 (Kirkpatrick (1982)), this allowed the comparison of behaviour under the influence of stress release only. Furthermore, slurry consolidation in this manner is usually thought to give excellent consistencies in moisture contents among samples and therefore good control in the testing program.

Remoulded kaolins have been used in most laboratory studies although kaolin is not a major constituent of natural clays. Illite was selected for this investigation because it is more common, and therefore represents the properties of real clays more closely.

The effective stress conditions at a soil depth of 10m with an overconsolidation ratio of 2.0, and a 40m water depth were modelled. These soil and water depths are typical (but not extreme) values for offshore geotechnical engineering on continental shelves. The background studies that led to the selection of these stresses and the overconsolidation ratio is detailed by Ambrosie(1984) and will not be repeated here.

3.3 MODELLING SAMPLING PROCEDURES

The stress release associated with sampling in the field was modelled in this laboratory investigation by completely unloading the total stress of the samples obtained after triaxial consolidation and back pressuring. It is perhaps useful at this point to quickly outline the stages involved in testing "insitu soils" and "samples". The test details will be described fully in Chapter 4. The stages can be briefly summarized as follows:

1. Consolidate slurries one-dimensionally to axial stress of 70kPa.
2. Extrude, trim the clay to approximately 75mm-diameter, 125mm-high specimens, and build into triaxial cells.
3. Consolidate triaxial specimens anisotropically (following approximate K_o stress path) to an effective vertical stress of 160kPa.
4. Offload the specimens following the same stress path, giving an overconsolidation ratio of 2.0.
5. Back pressure the specimens to 500kPa, simulating the seabed condition.
6. For the control samples, that is the "insitu soils", the undrained shear test is carried out at this stage.
7. For "samples" used to explore disturbance effects, the total stress is completely unloaded with the drainage closed.
8. Allow the samples to sit for a series of different dwell periods under this undrained condition.
9. Apply reconsolidation procedures and allow the "samples" to reach porewater equilibrium.
10. Test in undrained shear to measure the "sample" strengths.

Since the objective of the investigation was to model the sampling procedures used in practice, it is useful at this point to review the common procedures used by site investigation contractors regarding sample handling. Clay samples are extracted from the seabed using thin-walled sampling tubes. After these samples are hoisted on board the drilling vessel, some are immediately extruded for quality inspection and classification. The samples to be tested for undrained shear strength are either retained in the sample tubes or extruded and sealed, depending on the individual company doing the site investigation. The samples are then transported to the laboratory for subsequent testing.

Hvorslev(1949) recommended preserving the samples in the tubes to avoid disturbance caused by removal and handling of unprotected samples. Vyas et al(1983) suggested sealing the samples in sample tubes with airtight, expandable brass and rubber plugs. De Ruiter(1981) however argued that all samples should be extruded on board to check their quality and to select suitable portions for testing in the ship's laboratory or in the main laboratories on land. Semple and Johnston(1979) agreed that samples should be extruded in the field. They argued that more disturbance may occur in overcoming the adhesion between stiff clay samples and the sampling tubes when extruded in the laboratory after transportation and storage than when extruded and packaged in the field just after sampling.

Regardless of when the samples are extruded, the total stress release occurs in a relatively short period of time in comparison with the drainage time of low-permeability clays (Bishop and Henkel (1962)). Thus the samples are under undrained conditions during the unloading process. However, the behaviour of samples in sample tubes at various stages after sampling is relatively unknown. On the basis of his present understanding of sample behaviour, the author chose to restrict drainage from the test specimens.

3.4 MODELLING STORING PROCEDURES

Subsequent to sampling from the seabed, clay samples are either tested in ship-board laboratories or are transported to laboratories onshore. De Ruiter(1981) suggested that testing on board has definite advantages because of the shorter time lapse between sampling and testing, and leads to a greater chance that the results are representative. Although there is currently a trend to upgrade the equipment in on-board laboratories so that more complex tests can be performed, most existing on-board laboratories are only equipped to perform tests such as moisture content determination, Atterberg limits and unconfined compression tests.

In order to investigate the effect of the duration of dwell period between sampling and testing on undrained shear strength, three values of dwell time were selected for this study, namely 15 minutes (instantaneous), 1 day and 1 week. A dwell period of 15 minutes models high quality on board testing, which could probably be carried out in the future. High quality onshore testing is modelled by the 1-day dwell period. In this case, samples are transported to onshore laboratories on the same day they were taken from the seabed. They are then stored overnight and tested on the following morning. A dwell period of 1 week represents samples being stored in onshore laboratories for a relatively long period before testing is performed. In actual cases, samples might be stored for periods longer than 1 week. However due to time limitations, 1 week has been chosen to model this lower quality of testing practice.

During the dwell period, the drainage of the samples was kept closed. In the author's opinion, this procedure could model the case where the samples are left in the tubes during storing, and extruded just before testing. Inside the sample tubes, the samples are restricted in a confined space. Absorption of free water, which leads to swelling is reduced to a minimum. The drainage situation is therefore somewhat close to undrained. However, for the samples which are extruded from sample tubes immediately after sampling, and stored in a wrapped and sealed form, the drainage condition is more complex, possibly a combination of both drained and undrained. The undrained procedure used in this study therefore could not properly model the later situation. Since real storing practice can-not be completely modelled by either drained or undrained conditions, a choice had to be made between the two for the purposes of preparing a carefully designed set of laboratory tests.

It was decided to use undrained conditions during both the unloading and dwell procedures for this first-stage investigation. Furthermore, it was deemed important to be able to follow the stress path of the samples at any stage during testing, including unloading and dwell. With the equipment available in the Geotechnical Laboratories in the University of Manitoba, the stress path could be followed only with the drainage closed. No significant redesign of equipment was possible with time and financial constraints imposed on the project. In future research, drainage and measurement of porewater pressure (both positive and negative) should be facilitated by utilizing additional equipment. For example, by eliminating circumferential filter strips, allowing drainage from the top of the sample through the top cap, and measuring porewater pressure at the bottom of the sample through a pressure transducer mounted as before.

3.5 RECOVERING "INSITU" SHEAR STRENGTH

As stated in Chapter 2, different reconsolidation procedures have been suggested by various researchers to recover the "insitu" shear strengths of clays. The suggestions include isotropic reconsolidation from 0.5 to 1.0 times the insitu vertical stress, or anisotropic reconsolidation (K_o) to insitu stresses.

Three reconsolidation procedures were selected for this investigation, namely

1. isotropic reconsolidation to 0.6 times the insitu vertical stress,

2. isotropic reconsolidation to 1.0 times the insitu vertical stress, and
3. anisotropic reconsolidation to insitu vertical and horizontal stresses.

Again, since the objective was to reveal a convenient reconsolidation procedure to recover the "insitu" strength, isotropic reconsolidation (methods (1) and (2)) was emphasized due to its relative simplicity. Anisotropic reconsolidation was included to judge its success in the event that high quality testing is to be conducted. Although these reconsolidation procedures were partly researched in previous projects, the testing procedures used were not fully appropriate until recent work by Kirkpatrick (1982) as stated in Chapter 2. However, in the author's opinion some of the procedures adopted by Kirkpatrick did not adequately model the stress release procedures in the samples. For example, his "samples" were obtained by cutting specimens from blocks of clay using thin-walled tubes. Thus in addition to the process disturbance studied in this investigation, mechanical disturbance was also introduced. The reconsolidation procedures adopted by the author were therefore considered necessary in a search for the best method for recovering the "insitu" strength. Other procedures (for example isotropic reconsolidation to 0.8 times the insitu vertical stress) were also considered. However due to time limitations, only the three procedures mentioned above were selected.

3.6 OVERVIEW OF THE TEST PROGRAM

Stress states corresponding to 10m of soil depth with an overconsolidation ratio of 2.0, and a 40m water depth were modelled. Parameters under investigation were (1) dwell period, and (2) reconsolidation procedures. For each parameter, three values were selected, bringing the total number of specimens required to nine. Two control samples were also tested to facilitate comparison of behaviour between "insitu soil" and "samples". The procedures of unloading and dwell were eliminated for the control samples, such that the "insitu soil" behaviour was modelled. Other than the eleven overconsolidated samples tested, a parallel series of tests was conducted currently with the author's program by Ambrosie(1984) to study the behaviour of normally consolidated "insitu soils" and "samples" of the same clay. The total number of samples tested was therefore twenty-two. The results obtained from overconsolidated samples are reported in this thesis. Those obtained from normally consolidated samples can be found in Ambrosie(1984). The testing program is summarized in Table 1. The details of sample preparation and test procedures are outlined in Chapter 4.

Chapter IV

SOIL PROPERTIES, SAMPLE PREPARATION AND TEST PROCEDURES

4.1 INTRODUCTION

Samples of remoulded illitic clay tested in this investigation were prepared by one-dimensionally consolidating a slurry until an adequate strength to permit trimming was produced. The samples were then anisotropically consolidated in triaxial cells, followed by back pressuring to simulate the seabed condition. To model the disturbance introduced to offshore clay due to the sampling, storing and testing procedures, nine samples were prepared as described above and were then offloaded to near zero total stress under undrained conditions. Parameters studied were: the period of dwell time after unloading and the influence of different reconsolidation stresses during reloading. The results of these samples were compared with two control samples, in which the triaxial consolidation and back pressuring stages were followed immediately by undrained shearing (ie. no unloading and reconsolidation). This chapter provides a brief description of the index properties of the soil tested, and the sample preparation and testing procedures used in the study.

4.2 SOIL PROPERTIES

Eleven triaxial samples of remoulded clay from Grundy County, Illinois were tested in this investigation. The grey clay was received in disturbed form, in various sizes up to lumps of about 10cm, loosely packed in burlap bags.

X-ray diffraction tests indicated that the major minerals present in the clay are quartz, illite and kaolinite, with the proportion (by occurrence) of illite to kaolinite more than 5:1 (Figs. 4.1-4.4). Standard classification tests were performed on the clay. These are compared with those of "Grundite" (same as the soil tested in this investigation) tested by Wu et al(1983) in Table 2.

4.3 SAMPLE PREPARATION

4.3.1 Preparation of Remoulded Samples

All the remoulded samples tested in the present study were prepared by thoroughly mixing oven-dried, pulverized illitic clay with distilled tap water in a mechanical mixing unit (Fig. 4.5). Various researchers have reported that satisfactory results could be obtained by using different initial moisture contents for preparing the slurry (for example 2.0 x w_L -Lewin and Burland,1970; 1.5 x w_L-Kirkpatrick and Rennie,1972; 2.2 x w_L -Hambly,1972; Parry and Nadarajah,1973). There is no general agreement among researchers, however, as to what moisture content should be employed. It is usually thought that any moisture content within this range can lead to meaningful results depending on subsequent testing details. Since a moisture content of twice the liquid limit produced conclusive results for remoulded Winnipeg clay (Li,1983), and this proportion is quite widely used in European soil testing, a moisture content of 2 x w_L (w_L

=57.2%, Table 2) was selected for preparing the slurry in this investigation.

After being mixed in the vaccum container for five half-hour periods over three days, the slurry was poured into a consolidation cylinder (Fig. 4.6). It was then allowed to consolidate with top and bottom drainage under a vertical load applied through a hanger and dead weight system. The loading piston of the consolidation cylinder was equipped with two drainage leads to allow flushing of the filter stone if desired at any stage during the compression process.

Compression of the sample was accomplished in five increments starting from a vertical stress of 14kPa with a load ratio[4] of approximately 1.38. Vertical displacement was monitored with time throughout this compression process (Fig. 4.7). During the early stage of the testing program, a sample (T706) was allowed to reach equilibrium at one intermediate stress level, and again at the final stress level. Since the drainage paths in the samples were long (about 20cm at the start and 13cm at the end of the compression process), the equilibrium procedure was time consuming, often taking about eight days to complete. For this reason in later stages of the program, equilibrium was allowed only at the final stress level. Depending on the height of the slurry in the cylinder, the time required to reach equilibrium was not the same among samples. To define equilibrium, displacement vs. log(time) graphs were plotted continously during testing. Samples were assumed to reach equilibrium after secondary consoldation behaviour was observed in the test results. The total time required for the whole compression process was generally around two weeks if equilibrium was allowed only at the final stress level.

---

[4] Load ratio = new load / previous load

The adoption of the final cylinder stress of 70kPa was based on two reasons. Firstly, this stress level produced samples which had adequate shear strength to permit trimming in the triaxial cell. The ratio of s_u/σ'_{1c} ranges from 0.2 to 0.25 for many different soft clays (Larsson,1980; Trak et al,1980; Graham et al,1983). The vertical stress of 70kPa in the cylinder therefore produced an adequate shear strength for trimming of about 16kPa. Secondly, all samples were subjected to subsequent triaxial consolidation to a final axial stress of 160kPa. With a maximum stress of 70kPa at the cylinder consolidation stage, the clay could be reasonably expected to return to the virgin normal consolidation line prior to the final stress of 160kPa in the triaxial cell. This was later supported by test results obtained. On this basis, it could be assumed that the effects of unloading during trimming into the triaxial cell would be completely removed by subsequent triaxial consolidation, and the soil would behave as completely normally consolidated at 160kPa axial stress. Details for preparing remoulded clay samples including remoulding and consolidation are documented by Li(1983) and will not be repeated here.

4.3.2 Extrusion from Cylinder, Trimming and Building-in of Remoulded samples

A new piece of equipment (Fig. 4.8) was designed for the extrusion of samples from consolidation cylinders for this study. The aim of this equipment is to minimize disturbance introduced to the samples during extrusion and handling. The unit has two distinct features. Firstly, it allows full control of both the speed and the magnitude of the extrusion from the cylinder. Secondly, since the cutting cylinder is set up directly above the consolidation cylinder, trimming can take place at the same time as the sample is being extruded. This reduces the amount of handling of the extruded sample and thus reduces disturbance. Appendix A contains details of using the extrusion unit.

The importance of high quality sampling and testing techniques has been emphasized by several investigators (Crooks,1973; Graham,1974; Tavenas and Leroueil,1977). Although mechanical disturbance due to sampling is avoided in laboratory consolidated clay, disturbance associated with sample preparation and testing should be minimized if good results are to be obtained.

A sample size of 76mm diameter and 130mm high was used for this investigation. Equipment and testing procedures aimed at reducing disturbance for trimming and building-in of triaxial clay samples are well developed at the University of Manitoba. The important feature of the trimming equipment is that the top of the triaxial sample is supported throughout the process, thus minimizing disturbance. Detailed instructions for trimming and building-in procedures have been carefully described by Lew(1981). They can be briefly outlined as follows:

Before placing the cutting cylinder in the extrusion unit, the base plate of the trimming equipment was placed on the cell base and was adjusted until the inverted cutting cylinder was accurately centered over the pedestal. During extrusion, the excess clay outside the cutting edge was removed by trimming wire after the sample was jacked into the lightly oiled cutting cylinder. This process was repeated until soil protruded from the top of the cutting cylinder. The ends of the sample were then trimmed across the top and bottom of the cylinder. The sample was placed on a deaired filter stone located on the cell pedestal. The top cap was located firmly by a central clamping rod, and the cutting cylinder was removed. A series of 5mm wide drainage filter strips were applied longitudinally around the circumference of the sample. Two membranes, separated by a layer of silicone oil, were placed over the sample, and were secured in place by two O-rings on the top cap and three on the pedestal. The cell was then filled with deaired water and a 2cm thick layer of engine oil applied through the cell top to reduce leakage and friction build up in the piston bushing.

4.3.3 Triaxial Consolidation

The effective stress conditions at a soil depth of 10m and an overconsolidation ratio of 2 were modelled in this investigation. The 10m depth is typical of the soft clay veneer that is often found in contental shelves and the upper parts of submarine slopes. Assuming a unit weight of 18kN/m^3 for soil (γ_{sat}) and 10kN/m^3 for water (γ_w), thus giving a submerged unit weight (γ_{sub}) of 8kN/m^3, triaxial samples were consolidated anisotropically to a maximum vertical stress of 160kPa. Samples were then offloaded to a vertical stress of 80kPa, producing an overconsolidation ratio of 2.0. During both loading and unloading, a stress path with a fixed σ_3'/σ_1' ratio close to the coefficient of lateral earth pressure at-rest (K_o) was followed.

Different K_o values can be obtained using equations suggested by various researchers (for example, Jaky(1944), Brooker and Ireland(1965)). Although the K_o value for the clay tested could be estimated based on the ϕ' value reported by Wu et al(1983) and the equations suggested by the researchers mentioned above, it was decided to determine the K_o value experimentally by means of the triaxial tests in this investigation. The procedures involve adjusting the σ_3'/σ_1' (K) ratio at every load increment until the sample area remains approximately constant (i.e. zero lateral strain) between consecutive increments.

A K ratio of 0.57 was adopted for the first sample (T702). This produced a total lateral strain of 1.6% at the end of the triaxial consolidation. The lateral strain was considered large and the K ratio was therefore deemed higher than the K_o value. The K ratio was then adjusted to a range between 0.54 and 0.55 in later tests (Table 4). The ratios produced total lateral strains ranging from 0.7% to 1.0%. These stress ratios and lateral strains were initially thought to be adequately close to those associated with the K_o value. In order to determine the K ratio at which the total lateral strain would approach zero, sample T712 was tested using various K ratios ending at 0.46. This produced a total lateral strain of only 0.2%. However, large portion of this total lateral strain was produced at early stages of the triaxial consolidation when the K ratio was adjusted towards the 0.46 value. At the ratio of 0.46, the change in lateral strain observed during the last four load increments was about 0.04%. Since this K value of 0.46 was considerably different from that of around 0.54 used in previous tests, a decision had to be made to either (a) test all later samples at K=0.46, thus introducing a non-uniform set of data, or (b) continue the test program with K=0.53, accepting that all samples experienced some small lateral strains. It was decided to adopt a constant K ratio of 0.53 for subsequent samples to facilitate comparison of results. The K ratio of 0.53 generally produced total lateral strains of about 0.6% and a $\varepsilon_{1c}/\varepsilon_{3c}$ ratio of about 10 (Table 4). This indicated that the consolidation was certainly strongly anisotropic even though the K_o condition was not met during triaxial consolidation.

The remoulded samples all experienced a maximum vertical pressure of 70kPa during the cylinder consolidation stage. They were subsequently unloaded for trimming and reloaded in the triaxial cell. Triaxial consolidation permits the determination of the reload parameter κ, and a comparison to be made between the observed yield stress and the preconsolidation stress in the cylinder experienced by each sample. Starting with a vertical stress of 50kPa in the triaxial cell, the samples were consolidated to a maximum vertical stress of 160kPa in eight one-day increments with a load ratio of 1.15, similar to that used in earlier work in the University of Manitoba, for example by Lew(1981) and Li(1983). About three load increments were required to adequately establish the reload line (slope κ), and this explains why a starting vertical stress of 50kPa was adopted.

The triaxial consolidation tests were performed in triaxial cells set on a steel loading frame, the general arrangement of which is shown in Fig. 3.5 of Lew(1981). The frame can accomodate a maximum of three rotating bush cells at one time. Unfortunately, the rotating bushes of two of the cells did not function due to worn out bevel gears. Triaxial consolidation was therefore conducted on samples without the service of the rotating bush whenever these two cells were used. Since the author and his co-worker conducted tests concurrently, a smaller load frame was fabricated and a fourth triaxial cell was put into operation at later stages of the program. This fourth cell has a smaller piston than the others, and does not possess the service of a rotating bush.

To reduce the friction build up between the piston and the non-functioning rotating bush, modifications to the piston housing were performed on a triaxial cell (Fig. 4.9). There are two distinct features to this modification. Firstly, there is a comparatively larger clearance between the piston and the brass housing (0.005 in.) such that friction is reduced to a minimum. Secondly, a stiff lubricant is confined to the inner perspex container inside the cell. When the cell is pressurized, the lubricant is pushed upward by the cell water, filling the clearance between the piston and the housing, and thus further reducing friction. A mixture of light grease and engine oil was used on a trial basis. Since the grease does not float on the engine oil, a considerable amount of oil leaked from the cell during testing. Furthermore, tests showed that a friction of about 5% of the load applied to the sample existed during testing. This combination of constituents was not considered satisfactory. Further trials on different constituents and larger clearance between the piston and the housing are therefore required in future research testing programmes.

Dial gauges and burettes were used to monitor vertical displacements and volume changes of the samples. Before each loading increment, water was flushed through the drainage leads to remove air which might have been trapped in the cell base passages. This procedure is especially important for soils of high organic contents which have high gas-releasing potential. For the samples tested in this study, air bubbles were usually flushed out only during the first two or three load increments. This suggests that the air was not released by the soil, but was trapped during the building-in process.

Cell pressure were applied through deaired water in the cell, using compressed air to pressurize an external air-water tank. The cell pressure and the porewater pressure were monitored by pressure transducers, which were rezeroed before each load increment to atmospheric pressure at mid-height of the sample. Axial load was applied through the piston by a hanger and dead weight system. New loads were added at 24-hour intervals.

Upon reaching a maximum stress of 160kPa, the samples were unloaded in one step to an axial stress of 80kPa, giving an overconsolidation ratio of 2.0. The same K ratio as that adopted during the final loading increment was used for the stress ratio after the load decrease. Single-step unloading was selected to shorten the total time required for the triaxial consolidation process. At this final vertical stress of 80kPa, samples were again allowed to reach porewater equilibrium. To define equilibrium, the same criteria mentioned in section 4.3.1 for cylinder consolidation was again used, namely plotting log(time) vs. displacement graph and observing secondary consolidation behaviour. All samples were allowed to sit at this final stress level for a standardized period of four days. The equilibrium criteria defined above were met by all samples tested at the end of this four-day period.

The computations required for each load increment have been given in Appendix A of Noonan(1980). After the application of new axial and lateral stresses, axial dial and volume change burette readings were taken using satndard "doubling" time intervals (i.e. 1,2,4,8,15,30 min., 1,2,4, hr.etc.).

4.3.4 Back Pressuring

To simulate the porewater stress conditions of the seabed clay, all samples were subjected to high back pressures after triaxial consolidation. In this investigation, the stress states of 10m soil depth with an overconsolidation ratio of 2.0, and a 40m water depth were modelled. This stress state leads to an effective axial stress of 80kPa and a porewater pressure (in the form of back pressure) of 500kPa. (Sample T718 was subjected to a back pressure of only 400kPa due to the development of leakage of cell water between the cell top and the cell base at high pressure).

Before back pressuring, the drainage system was flushed again to ensure that any entrapped air was removed. Samples were then moved carefully from the consolidation frame to a compression frame. The piston was clamped before the hanger and dead weights were removed. The cell pressure, burettes, axial dial gauge, and transducer lines, however, were all kept in place. The axial load was re-established in the compression frame by means of a proving ring.

The back pressure of 500kPa was applied over a ten minute period in ten increments of 50kPa each. At every increment, the external cell pressure and the internal porewater pressure were increased by the same amount at approximately the same rate. The proving ring force was also increased to a value just enough to counterbalance the force exerted on the piston by the increased cell pressure. Samples were then allowed to sit under the back pressure for a period of approximately 24 hours. Volume strains experienced by the samples during back pressuring were generally less than 0.07%, and were therefore considered insignificant.

4.4 UNLOADING AND DWELL

(This section does not apply to control samples (T702 and T722))

The normal procedure of sampling, which involves pushing thin-walled tubes into the seabed to extract clay samples, introduces release of both the effective and porewater stresses from the clay. The unloading process was modelled in this laboratory investigation by releasing the total external pressure (cell pressure) while the drainage leads to the samples were closed off. As mentioned in Chapter 3, the project has specifically excluded from consideration the mechanical disturbance which is also associated with sampling in the field.

Unloading was completed in two stages, namely shear unloading and isotropic unloading. During shear unloading, the shear load was removed in six steps by means of adjusting the proving ring force while the cell pressure was kept constant. At the end of this stage, an isotropic stress condition was achieved. The sample was then subjected to isotropic unloading by reducing the cell pressure, usually in amounts of 50kPa until a cell pressure of 5kPa was reached. The proving ring force was also decreased by an amount to compensate for the decrease in cell pressure. The total time required for the unloading process was about 10 minutes. Complete unloading (that is to zero cell pressure) was not carried out. A small residual cell pressure of 5kPa was used to retain firm contact and volume control between the sample and the membranes.

During unloading, the porewater pressure and the axial displacement of the sample were monitored. There was initially some concern as to whether the pressure transducers were capable of measuring the negative porewater pressures generated during unloading. Tests and subsequent calibrations showed that they measured negative pressure with an error of about 3%. Furthermore, calibration showed that the positive range measurements of the transducers were not affected by previously experienced negative (tensile) pressures.

Following unloading, the samples were allowed to sit for dwell periods of either 15 minutes, 1 day or 1 week (Table 1) to simulate the time span between sampling and testing in the laboratory. Throughout this dwell period, the cell pressure was kept at around 5kPa, drainage leads remained closed, and the porewater pressure and the axial displacement were monitored. Behaviour of the samples during this dwell period will be discussed in Chapter 7.

4.5 RECONSOLIDATION AND UNDRAINED SHEAR

In order to determine the undrained shear strength of clay, samples are usually subjected to undrained shear tests after being consolidated to different stress levels. Three reconsolidation procedures have been selected for this study, namely isotropic consolidation (1) to 0.6 and (2) to 1.0 times the insitu axial stress, and (3) anisotropic (K_o) consolidation to insitu stresses. The objective of this study is to determine which reconsolidation procedure can best recover the insitu shear strength of the clay.

Reconsolidation was completed in two stages, namely the consolidation stage and the back pressuring stage. For both isotropic and anisotropic samples, the cell pressure was first increased in one increment to its designated value. During this increase in cell pressure, the porewater pressure was monitored continously. The drainage was opened once the porewater pressure increased from negative to zero. Upon reaching this isotropic pressure condition, samples to be consolidated isotropically were subjected to back pressuring. For samples to be consolidated anisotropically, the extra axial stress required was established by increasing the proving ring load. All samples were then subjected to the normal level of back pressuring (200kPa) used commonly in commercial and research laboratories to achieve higher saturation before undrained shearing. The 200kPa back pressure was applied in four increments of 50kPa each. Procedures for back pressuring were described in section 4.3.4 and will not be repeated here. Axial and volume strains experienced by samples during this reconsolidation period varied depending on the reconsolidation procedures and dwell time. This will be further discussed in Chapter 7.

Samples were usually allowed to sit under the reconsolidation stresses and the back pressure for 24 hours. Axial displacements and volume changes were monitored during this reconsolidation period. Before undrained shearing, samples were checked for saturation using the standard "B test". After 24 hours of reconsolidation, Sample T708 showed a porewater response (B) of 0.91 only. Air bubbles of about 1.5cm^3 volume were then flushed out from the drainage leads. In order to allow for porewater equilibrium, the sample was consolidated for a further 24 hours. For some of the samples which experienced 1 day or 1 week dwell period, an elapsed time of about 5 minutes was required before the B value could reach an acceptable value (eg. 0.97).

Undrained shearing was carried out at a rate of about 0.5%/hour. Readings of axial deflection, proving ring, porewater pressure and cell pressure were taken at 10 minutes intervals, so the "elastic" part of the stress-strain graph could be well defined. For samples tested in cells without the service of the rotating bush, the piston was rotated back and forth once by hand for about three-quaters of a turn either way before proving ring and axial displacement readings were taken. This procedure reduces friction build-up between the piston and the non-functioning rotating bush. A difference of about 5 divisions in the proving ring reading (an equivalent stress difference of about 1.5kPa) was usually observed before and after rotating the piston. The proving ring load usually increased at a slower rate after about one hour of shearing. Readings were then taken at 15 minute intervals. The intervals were further extended to half hour after about 2% of axial straining. A relaxation test (Kenney,1966) was carried out at about 3% axial strain. A peak in the proving ring force was observed before the relaxation test was conducted. The relaxation procedure involves switching off the compression machine and recording changes with time in axial deflection, proving ring load, porewater pressure and cell pressure. Stopping the compression machine allows the sample to continue straining at a decreasing rate by the stored energy in the proving ring. Relaxation was continued overnight. On the following morning, the compression machine was switched on again and shearing continued. Readings were taken frequently (eg. every 10 minutes) during the first hour of re-shearing. Intervals were then extended to 20 minutes, 30 minutes and 1 hour towards later stages. Shearing was usually allowed to continue overnight without supervision to an axial strain of about 15% on the following morning. After final readings were taken, the failed samples were removed from the triaxial cells. Samples were then cut and prepared for the determination of final moisture contents. The moisture content profile across failed samples and the reliability of this method of determination will be discussed in Chapter 7.

Chapter V

CONSOLIDATION TEST RESULTS

5.1 INTRODUCTION

A total of nine triaxial specimens (T704-T720, even numbers only) was tested to model the effects of stress release on "samples" which simulate those collected during site investigation in offshore clays. The duration of the dwell period between sampling and testing, and the reconsolidation procedures used in the laboratory before undrained shearing were both introduced as parameters in the testing program. The results obtained were compared with those of two control samples (T702 and T722). These samples were tested directly in undrained shear, without the unloading procedure to model the undisturbed "insitu soils".

As described in Chapter 4, samples for triaxial testing were obtained by first consolidating slurries in cylinders until an adequate strength was reached. They were later trimmed and built into triaxial cells. This chapter reports the results obtained during the slurry consolidation and triaxial consolidation stages of the tests. The results include one-dimensional consolidation parameters (λ and κ), yield stresses, and equivalent isotropic elastic moduli (K_{eq} and G_{eq}). Discussion of the results will be presented in Chapter 7.

5.2 SLURRY CONSOLIDATION (λ_1 -VALUES)

Values of the compression index λ can be obtained from samples during slurry consolidation as outlined in Chapter 4. The slurries were compressed in cylinders with vertical stresses increasing from 14kPa to 70kPa in five one-day increments. The final 70kPa stress was held constant until secondary consolidation behaviour was observed as described in Chapter 4. Graphs of $\log(\sigma_v)$ vs w for slurry consolidation are presented in Figures 5.1 to 5.5. These graphs were approximated by straight lines, and their slopes converted to the commonly used parameter λ (natural logarithms and void ratios) for normally consolidated soils. They are termed λ_1 in this investigation to indicate their origin in the slurry consolidation stage. The λ_1-values are presented in Table 3.

It was pointed out in Chapter 4 that all samples were allowed to reach equilibrium at the final stress of 70kPa. In sample T706, equilibrium was also allowed at one intermediate stress. For this reason, the $\log(\sigma_v)$ vs w graph for T706 has not been presented here, and the σ_1 value is therefore not available.

Figures 5.1 to 5.5 show that most samples exhibited a curved stress-strain response during the first one or two load increments, followed by a linear response in the 3 to 4 increments before the maximum stress was reached. Virtually straight lines in $\log(\sigma_v)$,w-space were obtained for samples T718 and T720 throughout the whole compression process. The λ_1 -values in these tests varied from 0.726 to 0.532, with an average of 0.621 and a standard deviation of 0.055. Table 3 also shows that there is a considerable range of moisture contents among the samples 24 hours after the final load application of 70kPa. The moisture contents at this stage ranged from 65.3% to 50.6% with an average of 58.3% and a standard deviation of 5.2%. However after allowing the samples to sit under the final stress of 70kPa for a dwell period, the moisture contents became less variable (from 52.1% to 45.8% with a standard deviation of 2.0%). During this period, samples with low values of λ_1 (for example T716) compressed by larger amounts than other samples with high values of λ_1 (for example T708). This implies that drainage from the samples was not completely identical in all cases, and some samples were clearly still consolidating actively during the dwell period.

5.3 TRIAXIAL CONSOLIDATION

5.3.1 Introduction

After the final period at constant stress of 70kPa, samples were extruded from the cylinders, trimmed to 76mm diameter samples and built into the triaxial cells as described in Chapter 4. They were subsequently consolidated anisotropically following approximate K_o stress paths to a maximum vertical stress of 160kPa. Since overconsolidated samples were to be tested in this project, all samples were then offloaded along the original loading stress paths to stresses that gave an overconsolidation ratio of 2.0 (Chapter 4). The results obtained during triaxial consolidation stage are presented in the following sections.

5.3.2 Linear and Volume Strains

As mentioned in the previous chapter, the K (σ_3'/σ_1') ratios of the samples varied from 0.57 to 0.46 with the majority of samples tested under K ratios of around 0.53 (Table 4). During triaxial consolidation, the axial deflection and volume change of the samples were measured, so that axial strains and volume strains could be calculated at any stage during testing. Lateral strains were calculated on the assumption that the samples remained cylindrical after deformation. Under real K_o consolidation, the cross sectional areas of the samples should remain constant, thus leading to zero lateral strains. However absolute zero lateral strain was impossible to control with the equipment available, and small amounts of area decrease were therefore inevitable. The ratios of $\varepsilon_{1c}/\varepsilon_{3c}$ are also presented in Table 4. A higher value of the ratio indicated that the consolidation was closer to the K_o condition. Depending on the K ratio adopted for each sample tested, the $\varepsilon_{1c}/\varepsilon_{3c}$ values varied from 5.8 to 48.5. This will be further discussed in Chapter 7.

5.3.3 Values of κ_1

Although the equipment used and the procedures adopted in the investigation were aimed at reducing mechanical disturbance during trimming into the triaxial cells, stress release leading to swelling of the samples was inevitable. In order to be able to meaningfully compare the behaviour of "insitu soils" and "samples" as finally prepared, careful control of consolidation procedures was mandatory. Consolidation in the triaxial cells started from a vertical stress of 50kPa. Since the maximum vertical stress during the previous cylinder consolidation was 70kPa, triaxial consolidation allowed the determination of the slope of the reload line (denoted by κ_1). All κ_1 -values are presented in Table 4. These values are obtained from the straight line portions of the log(p') vs V graphs (Figs. 5.6-5.11) at stresses less than 70kPa. The κ_1 -values for samples T704, T712 and T722 are not available since straight portions were not observed in the plots for these samples. For the other samples, the κ_1-values ranged from 0.168 to 0.072 with an average of 0.103 and a standard deviation of 0.030. Sample T702 showed an exceptionally high κ_1-value. Neglecting this sample, a standard deviation of 0.016 was obtained for the remaining κ_1-values.

5.3.4 Values of λ_2

Triaxial consolidation continued beyond the cylinder preconsolidation stress of 70kPa to a maximum vertical stress of 160kPa. Determination of the slopes of the normally consolidated lines (λ_2-values) in log(p')vs V graphs was therefore possible. The λ_2-values are shown in Table 4. Since a straight portion was not observed for sample T704, the λ_2-value was not obtained. For the remaining samples, the λ_2-values were more consistent as compared with the λ_1- and κ_1-values. They ranged from 0.246 to 0.202 with an average of 0.226 and a standard deviation of 0.017.

5.3.5 Values of κ_2

All samples were unloaded following the original stress paths to create an overconsolidation ratio of 2.0. One-step unloading was adopted due to time limitations as described in Chapter 4. A standardized period of 4 days was also allowed such that the samples could reach equilibrium after unloading. The κ_2-values reported in Table 4 were calculated from the 24-hour unloading curve from vertical stresses of 160kPa to 80kPa. The κ_2-values are the least variable among all the λ - and κ-values reported in this chapter. They ranged from 0.055 to 0.043 with an average of 0.0476 and a standard deviation of 0.0076.

5.3.6 Yield Determination

As described in previous sections, triaxial consolidation permitted the determination of the slopes κ_1 and λ_2 from log(p') vs V graphs. Furthermore, the yield stress (when the clay changed from a stiffer to a more flexible response) could also be identified. In this investigation, the preconsolidation pressure of 70kPa experienced by the clay during its previous slurry consolidation was well defined by the cylinder consolidation procedures. It is of interest to compare the yield stress obtained from the triaxial tests with the known preconsolidation pressure in the cylinder.

The triaxial consolidation data were analyzed using the computer program TXCEP. This program includes calculations of the energy absorbed by the samples during consolidation and is basically the same as that used by Lew(1981) and Li(1983) except for some small changes made by the author. These include improvments to the appearance of the figures and the addition of sample number to the plots. The basic algorithms were not changed. The program produces printouts of the results and seven different stress-strain plots which can be used for yield stress determinations. The plots include:

1. log(p') vs V (Fig. 5.6-5.11);
2. p' vs v (Fig. 5.12-5.14);
3. q vs ε (Fig. 5.15-5.17);
4. σ_1 vs ε_1 (Fig. 5.18-5.20);
5. σ_3 vs ε_3;
6. p' vs ε_1 (Fig. 5.21-5.23) and
7. W vs LSSV (Fig. 5.24-5.26).

This section only presents the results associated with consolidation yield points obtained from these plots. The data associated with unloading and dwell will be presented and discussed in Chapter 7.

Yield stresses were identified using bilinear plotting techniques described by Graham et al (1982). For comparison purposes stresses and energies at yield obtained from the plots were converted to a common variable, namely the effective vertical stress (Table 5). Conversion to σ_1' was accomplished by applying the corresponding K ratio for each sample near the yield point. The criterion of σ_3 vs. ε_3 was omitted from Table 5 since no yield stress could be determined from this plot in any of the eleven samples tested. Places marked "not available" in Table 5 indicate that bilinear behaviour was not observed in the plot, and the yield stress could not therefore be identified. If the yield stress can be identified from a specific criteria, an arrow is shown in that stress-strain plot to indicate the yield location.

For sample T712, the yield stress could be determined only from the W,LSSV criterion. The K ratio at yield for this sample was 0.474, which was the lowest among all samples tested. The W,LSSV plot proved to be a useful criterion since it permitted identification of yield points for all the samples tested. It should be pointed out that previous researchers at the University of Manitoba (Lew(1981) and Li(1983)) demonstrated that yield stresses could be interpolated through the energy variable W (y-axis) only but not through the stress vector length variable LSSV (x-axis).

An average yield vertical stress was obtained for each sample on the basis of all the yield stresses defined by the various criteria. These average yield stresses were compared with the preconsolidation stress of

70kPa and percentage differences were calculated. An average difference (absolute values were used) of 3.3% was obtained. The average yield stresses from the stress-strain plots were higher than 70kPa for all samples except for T712 in which the average was 1% lower. Further discussion on the determination of yield stresses and the relationships between the K ratio and yield stresses will be presented in Chapter 7.

5.3.7 Elastic Parameters

In order to describe cross-anisotropy of clays by means of anisotropic elastic theory, five elastic parameters are needed (Graham and Houlsby(1983)). However this requires stressing along stress paths in widely differing directions in p',q-space. The consolidation results reported here are only for stress paths close to the K_o-condition. It is therefore not possible to determine the full range of anisotropic elastic parameters. Equivalent isotropic pseudo-elastic bulk and shear moduli, K_{eq} and G_{eq} can be obtained from pre-yield linear sections of p',v and q,ε plots respectively obtained during triaxial consolidation (for example Fig. 5.12 and Fig. 5.15). Values of these parameters are presented in Table 4. Although it was not possible to identify yield stresses for some samples from the p',v and q,ε plots, nevertheless reasonably straight stress-strain behaviour was observed in the initial stiffer sections in all the test results. K_{eq} and G_{eq} values could therefore be calculated for all samples (Table 4). Since the stiffness of lightly overconsolidated clay depends on the preconsolidation pressures, normalized values of K_{eq}/σ'_{cyl}, G_{eq}/σ'_{cyl} are also shown in Table 4. During this stage of triaxial consolidation, the preconsolidation pressure experienced by the clay was the value of 70kPa during slurry consolidation. This explains why σ'_{cyl} was used as the normalizing stress. Further discussions on the moduli values will be presented in Chapter 7.

Chapter VI

UNDRAINED SHEAR TEST RESULTS

6.1 INTRODUCTION

After triaxial consolidation, the samples identified earlier as "insitu soils" and "samples" were transferred to a 10kN strain-controlled frame for undrained shearing to failure in triaxial compression. This permitted the determination of the differences in shearing behaviour between the undisturbed "insitu soils" and the disturbed "samples". "Samples" were subjected to unloading, dwell swelling and reconsolidation before undrained shearing was performed. For the "insitu soils" (control samples T702 and T722), shearing followed triaxial consolidation without the unloading step. The design of the testing program and the procedures used for testing were detailed in Chapters 3 and 4 respectively.

To ensure full saturation of the samples prior to shearing, a back pressure of 200kPa was applied in the manner described in Chapter 4. This value of back pressure is common in many research and commercial laboratories. Values of the porewater pressure parameter B at the end of back pressuring are tabulated in Table 6. The measured values of B can generally be considered satisfactory.

Normalized undrained stress-strain curves are presented in Figures 6.1 to 6.11. A summary of the undrained test results is given in Table 6. The undrained shear tests provide information on the stress-strain behaviour and the porewater pressure parameters of the clay. Properties examined include the undrained shear strength, the porewater pressure parameter A_f, the strain rate parameter $\rho_{0.1}$, and the elastic modulus E_{50}. The tests also permit an evaluation of the overconsolidated Coulomb-Mohr rupture envelope of the clay. When taken in conjunction with results obtained by Ambrosie(1984), the tests permit determination of the rupture envelope for both normally consolidated and overconsolidated illitic clay for the given preconsolidation pressure of 160kPa.

The following sections present these undrained shear results in more detail. A discussion of the results is given in Chapter 7. To reduce confusion, the following codes will be used in identifying the "insitu soils" and the "samples" which have been subjected to different reconsolidation procedures.

1. Group 1 - control samples (T702 and T722);
2. Group 2 - reconsolidation to 0.6 x σ'_{1c} CIU (T704, T706 and T708);
3. Group 3 - reconsolidation to 1.0 x σ'_{1c} CIU (T710, T712 and T714);
4. Group 4 - reconsolidation to 1.0 x σ'_{1c} CK_oU (T716, T718 and T720).

6.2 STRESS-STRAIN RELATIONSHIPS

Table 4 shows the stresses on each sample at the end of triaxial consolidation and the resulting strains at that stage of the test. The duration of the dwell period and the reconsolidation procedure selected for each sample are presented in Table 6. This table also shows the linear and volume strains experienced by the samples during reconsolidation. Graphs of $(\sigma_1 - \sigma_3)/2\sigma'_{vc}$, σ'_1/σ'_3 and $\Delta u/\sigma'_{vc}$ versus ε_1 are shown in Figures 6.1 to 6.11. The effective stress paths in p',q space are shown in Figures 6.12 to 6.15. Table 6 summarizes the values of various strength and deformation parameters determined from the tests.

The stress-strain curves for all the tests (Figs. 6.1-6.11) appear at first sight more discontinous than is commonly expected. This irregularity is caused by relaxation tests that were used to investigate the influence of changes in strain rate on the measured parameters. This will be reported in section 6.6. Although all the samples were overconsolidated with an overconsolidation ratio of 2.0, maximum values of q[5] are not easily identified from the stress-strain curves. Table 6 shows that the maximum deviator stresses interpreted from Figures 6.1 to 6.11 occurred at axial strains ranging from 1.7% to 6.9%. It should be pointed out that after relaxation tests, the deviator stress increased to higher values than before straining was stopped. When about 1% of axial strain had been added after restarting the shearing, the stress-strain curve typically returned to the line which would have been followed if the relaxation test had not been performed. The peak q-values developed during this stage immediately following the relaxation test have not been included in the determination of the maximum deviator stresses shown in Table 6.

As compared with the "insitu soils", the deviator stresses of the "samples" occurred at markedly larger axial strains. This agrees with the higher failure strains for "samples" than for "insitu soils" measured for example by Okumura (1970) and Kirkpatrick (1983). For Group 4 samples, the maximum deviator stresses occurred at strains rather closer to those of the "insitu soils". Strain softening behaviour was observed in all samples after the maximum deviator stress was reached. However, the reduction in shearing resistance from maximum q to the end of the test was not as large as observed for example by Li (1983) in remoulded Winnipeg clay.

---

[5] $q = (\sigma_1 - \sigma_3)$

Strain hardening behaviour was observed in test T712. A leakage in the drainage valve is thought to have occurred at an axial strain of around 1% for this sample. This view is supported by the sudden drop in the Δu vs. ε_1 graph shown in Fig. 6.6. In addition, the uncharacteristic continuous strain hardening in the stress-strain curve for this sample also suggests that the latter part of the test experienced some leakage and reduction in porewater pressure. For the other two samples in the same group (T710 and T714), strain hardening behaviour was observed until axial strains of about 3% were reached. Strain softening behaviour was observed at larger strains.

The wide range of axial strains where the maximum deviator stresses were observed in different tests, and the combination of strain softening and strain hardening behaviour that were encountered led to problems in using the maximum deviator stress as the criterion for failure. All the stress-strain plots exhibited an initial stiff section, then a more flexible response. The break between the two types of response usually occurred at axial strains of about 1% to 1.5%. The stress where the maximum curvature was observed in the stress-strain plot has been termed the "yield" deviator stress in this investigation, and has been evaluated for all samples for comparison of the "failure conditions". The yield point during undrained shearing for each sample is identified by the first arrow shown in the stress-strain plots (Figs. 6.1-6.11), that is at the lower value of ε_1. (The second arrow in each plot shows the location of the maximum deviator stress for that sample). The yield deviator stresses occurred at axial strains ranging from 0.65% to 1.71% (Table 6). The trend that the "samples" had larger yield strains than those of the "insitu soils" was again observed here. The yield strains were fairly consistent among the samples in each of the four groups tested. The yield strains observed from the samples in Group 4 were again closer to those of the control samples.

6.3 EFFECTIVE STRESS PATHS

The effective stress paths of the samples are presented in Figures 6.12 to 6.15. Stress paths of the samples subjected to the same reconsolidation procedure are presented in one figure. The influence of overconsolidation is clearly demonstrated by all the effective stress paths. The paths generally move almost vertically upwards from the end of reconsolidation stresses, and then move to the right during later stages of shearing. However the stress paths of T702, T710 and T712 move abruptly to the right after the start of undrained shearing (Figs. 6.12 and 6.14), and then move to the left at larger strains. Sample T702 was subjected to a back pressure of 500kPa to simulate the seabed condition. Before shearing, the back pressure dropped to 475kPa overnight due to control problems and was adjusted back to 500kPa before testing. A period of around 2 hours was allowed between readjustment of the porewater pressure and shearing. However, porewater pressure equilibrium was probably not re-established at the beginning of testing. This led to the sudden drop in porewater pressure at the start of shearing, and the shifting of the stress path to the right. No clear reason was found to explain the abrupt drop of the initial porewater pressures in samples T710 and T712. As mentioned in the previous section, leakage through the drainage valve is suspected to have occurred in sample T712 during shearing. This view is supported by the sudden shift of the stress path to the right at about q=80kPa, and the subsequent slope of the stress path (approximately 3:1) which is characteristic of a drained test.

The strain softening behaviour of T702, T710 and T712 is accompanied by the stress paths shifting to the left towards the end of the tests. The post-failure strain softening of the remaining samples produces stress paths that are rather close to the initial stress paths during pre-failure loading. For samples in Group 2 and Group 4, the stress paths in each group are bunched together (Figs. 6.13 and 6.15). The duration of the dwell period between unloading and shear testing seems to have no effect on the shape of the effective stress paths in these cases. For the other two groups, the relationship of the dwell period and the shape of the stress paths could not be assessed due to the abrupt decrease in porewater pressure in some of the samples described previously.

6.4 POREWATER PRESSURE GENERATION

The relationships between the normalized changes in porewater pressure ($\Delta u/\sigma'_{vc}$) and the axial strain (ε_1) for all the undrained shear samples are given in Figures 6.1 to 6.11. Except for Group 3 samples, the porewater pressures rose to a maximum before the previously defined yield deviator stress was reached. The porewater pressures of these samples generally remained constant or exhibited a slight decrease beyond the peak value to the end of test at large axial strains of about 15%. Leakage was encountered in test T712 as described before. For samples T710 and T714, the porewater pressures increased more quickly during the early stages of the tests than in other tests. The porewater pressures for these two samples continued to rise until the end of shearing (Figs. 6.5 and 6.7).

The porewater pressure parameter $A=\Delta u/\Delta(\sigma_1 - \sigma_3)$ (Skempton(1954)) was obtained from each test at the yield stress and is presented in Table 6. The sudden drop of the initial porewater pressure in samples T702, T710 and T712 was treated as a "zero shift" for the calculation of the A_f-values. In other words, the porewater pressures immediately after the drop were considered to be the initial porewater pressure for the purpose of calculation. Table 6 shows that the A_f-values can be grouped according to the reconsolidation procedures. Samples in Group 1 and Group 4 showed rather close A_f-values, and were the lowest among all the samples tested with an average of around 0.19. Group 2 samples showed higher A_f-values with an average of around 0.25. Highest A_f-values were obtained from samples in Group 3. The average was around 0.35 for this group. Samples which had been allowed 1 week for the dwell period (T708, T714 and T720) showed the highest A_f -values as compared to the other two samples (15-minute and 1-day dwell periods) in the corresponding groups. This is however contrary to the conclusion drawn by Kirkpatrick (1982) that A_f-values decrease with sample age. Further discussion of this topic will be presented in Chapter 7.

Porewater pressure behaviour has also been examined in terms of normalized changes in porewater pressure ($\Delta u/\sigma'_{vc}$) versus the change in octhedral total normal stress ($\Delta p/\sigma'_{vc}$) (Figs. 6.16-6.19). These graphs are again presented in groups according to the reconsolidation procedure. For all samples except T702, T710 and T712, the relationship is approximately linear up to a high percentage of the maximum shear stress. For the three non-typical samples, the curved initial relationship is probably due to the porewater pressure stabilization problem at the beginning of testing that was described previously. Shortly after the beginning of these tests the relationship changed, and became linear like the other samples. The gradients m of the linear sections of $\Delta u/\sigma'_{vc}$ vs $\Delta p/\sigma'_{vc}$ are summarized in Table 6. They range from 0.82 to 1.56 with an average of 1.17 and a standard deviation of 0.23. Except for samples T702 and T708, all m values are higher than 1.0.

For Group 3 samples, the porewater pressures rose continously as shown in Figure 6.18. For the remaining samples, the porewater pressures dropped during later stages of the tests, hooking the $\Delta u/\sigma'_{vc}$ vs $\Delta p/\sigma'_{vc}$ curves downwards to the right (Figs. 6.16, 6.17 and 6.19). This is characteristic of overconsolidated samples. Sample T702 shows a temporary decrease in porewater pressure followed by an increase at an axial strain of around 1.5% during shearing. The reason for this behaviour is unclear. One possible explanation is that the pressure transducer had undergone a temporary zero shift. As mentioned earlier a leakage problem developed in test T712. Figure 6.18 shows clearly that the porewater pressure dropped suddenly during shearing of this sample.

6.5 ELASTIC MODULUS

In the present study, the non-linearity of the $(\sigma_1 - \sigma_3)$ versus ε_1 curves from undrained shearing tests has been approximated by a secant modulus E_{50}. The value of E_{50} was calculated between the starting point and 50% of the yield deviator stress in each stress-strain plot. Values of E_{50} have been normalized using half the yield deviator stress $(0.5q_y)$ to give the equivalent of what is often known as the relative stiffness, E_{50}/s_u. Table 6 summarizes all values of E_{50} and $E_{50}/0.5q_y$. Both sets of values are consistent among the samples in each group, except for high values associated with sample T722. Different reconsolidation procedures seem to have some effects on the E_{50} and the $E_{50}/0.5q_y$ values. Samples in Group 4 showed the lowest values.

6.6 STRAIN RATE EFFECT

Changes in straining rate during undrained shearing of carefully sampled natural clay have been shown to cause large variations in the undrained shear strength (Bjerrum et al(1972), Graham et al(1983b)). In the present study, the strain rate effect on remoulded samples was examined using the relaxation test described by Kenney(1966).

The strain rate effect can be represented by a parameter $\rho_{0.1}$, which describes the percentage change in shearing resistance caused by a ten fold decrease in strain rate, using the shearing resistance at a strain rate of 0.1 percent/hour as the reference strength.

In this investigation, relaxation procedures were performed on all the samples tested. The $\rho_{0.1}$ values obtained are shown in Table 6. They range from 3.8% to 10.6% (Fig. 6.20). Due to a non-uniform set of data collected during the relaxation test in T712, the $\rho_{0.1}$-value of this sample is not available. Although the relaxation tests were started at around the same axial strain ($\varepsilon_{\rho s}$, Table 6), the results show a significant scatter. This is common in most relaxation testing. The $\rho_{0.1}$-values from these tests on remoulded samples are rather lower than the range of about 10% to 15% reported by Graham et al(1983b) for natural clays. (Li(1983) also showed low $\rho_{0.1}$-values (5.4% to 8.2%) in remoulded Winnipeg clay.) Only one relaxation test was performed on each sample. No evidence is therefore available for these tests regarding the common tendency for $\rho_{0.1}$ to decrease with increasing axial strain.

Chapter VII

DISCUSSION OF RESULTS

7.1 INTRODUCTION

This thesis has investigated the effects of stress-release disturbance on the shear behaviour of offshore clay samples. It is aimed at searching for laboratory procedures which can best recover the insitu strength of the clay. The test results were reported in detail in Chapters 5 and 6 with only a minimum of discussion. In order to have a clearer understanding of the clay behaviour, the test results will be further examined in this chapter.

7.2 ONE-DIMENSIONAL SLURRY CONSOLIDATION

The procedures used in this investigation for preparing, mixing and consolidating the slurries were detailed in Chapter 4. The moisture content of each sample at the slurry stage after mixing is shown in Table 3. The moisture contents at this stage were within 1% of the intended value of 114.4% (twice the liquid limit) except for samples T708 and T716 in which the moisture contents were around 4% lower.

Graphs of $\log(\sigma_v)$ vs w for slurry consolidation were presented in Figures 5.1 to 5.5. The slopes λ_1 of the straight portions of these graphs (converted to natural logarithm and void ratios), are shown in Table 3. It should be pointed out that "λ" is commonly used for the critical state parameter which indicates the compressibility of the material in $\ln(\sigma_v'),e$ space. However due to time limitations in this investigation, complete porewater pressure dissipation was not attempted at each of the loading stages. The samples were therefore under-consolidated except at the end of the dwell period at the maximum vertical stress of 70kPa. The λ_1-values obtained from Figures 5.1 to 5.5 are therefore simply the slopes of the graphs in $\ln(\sigma_v)$,e space and should not be expected to agree with λ_1-values from complete consolidation. As pointed out in Chapter 5, the λ_1-values varied over a considerable range from 0.532 to 0.726 even after consistent loading procedures.

At the end of slurry consolidation, measured moisture contents were compared with the moisture contents calculated from vertical displacement readings. Table 3 shows that there is no clear relationship between the two sets of values which usually agreed to about 3% moisture content. Since the intermediate moisture contents in Figures 5.1 to 5.5 were obtained by calculations based on vertical displacements, this suggests that the λ_1-values reported in Table 3 can vary by only about ±0.03 as a result of this difference between measured and calculated moisture contents. Earlier attempts by Li (1983) to calculate moisture content changes through measurements of expelled water were unsuccessful due to leakage past the piston.

Consolidation of remoulded slurry samples is usually thought to give excellent control in moisture contents among samples. However the λ_1-values observed and the moisture contents measured in this investigation clearly suggests that the drainage conditions from the samples were not completely identical in all cases. This led to unequal amount of excess porewater pressure dissipation during compression. Some samples were therefore still actively consolidating during the equilibrium period compared with other samples. Further work in this area is urgently required to improve the moisture content consistency of the samples.

7.3 TRIAXIAL CONSOLIDATION BEHAVIOUR

7.3.1 Laboratory Determination of K_o Values

Wu et al (1983) suggested a friction angle $\phi'=25^\circ$ for illite. It was pointed out in Chapter 4 that although the K_o-value can be estimated using equations suggested by various researchers, experimental determination of the normally consolidated K_o was conducted in this study. This involved adjusting the ratio $K=\sigma_3'/\sigma_1'$ at every load increment until the sample area remained constant between consecutive load increments. Possible criticisms of this method include (1) the top and bottom end platens introduce restraints at the ends of the samples, and (2) zero strain along the sample length and throughout the test is difficult to maintain. Kirkpatrick (1982) measured K_o using a load cell placed on the side of one of his oedometer assemblies. For more accurate measurements of K_o in the triaxial apparatus, strain gauges which connect to a servo mechanism controlling the cell pressure can be used. The cell pressure is automatically adjusted so that the lateral strain of the sample remains zero throughout the test. This equipment was not available in the present study. Absolute zero lateral strain was therefore impossible to achieve.

7.3.2 Linear And Volume Strains

Although the zero-lateral-strain situation was found to correspond to a K ratio close to 0.46 during triaxial consolidation, the actual K ratios adopted during the tests varied from 0.57 to 0.46 with the majority of samples tested with K ratios of around 0.53 (Table 4). The background leading to the selection of the K ratios was discussed in Chapter 3. Table 4 also shows the ratios of $\varepsilon_{1c}/\varepsilon_{3c}$ measured at the end of triaxial consolidation. A higher ratio indicates that the consolidation was closer to the zero-lateral-strain condition. Depending on the K ratio used, the

$\varepsilon_{1c}/\varepsilon_{3c}$ value varied from 5.6 to 48.5. The strain ratio showed a general trend of increasing with decreasing K. Figure 7.1 shows that except for two uncharacteristic strain ratios exhibited at K=0.53, the relationship between $\log(\varepsilon_{1c}/\varepsilon_{3c})$ and K could be approximated by a straight line for the small range of K values in this investigation. However there is a limitation to this relationship. At K_o, zero lateral strain causes the $\varepsilon_{1c}/\varepsilon_{3c}$ ratio to approach infinity. The relationship should therefore be asymptotic to the $K=K_o$ line in arithmetic scale, and undefined at $K < K_o$ in logarithmic scale.

It was also found that a straight line relationship exists between log(K) and the average $\Delta\varepsilon_3/\Delta\varepsilon_1$ of the last three load increments during triaxial consolidation. The average $\Delta\varepsilon_3/\Delta\varepsilon_1$ value corresponding to K=0.46 was less than zero, indicating that the 0.46 value was rather less than the actual K_o value. A least-square analysis gives K=0.49 for $\Delta\varepsilon_3/\Delta\varepsilon_1 = 0$, suggesting that the actual K_o value is 0.49. It is interesting to note that this K_o value is close to the value of 0.51 suggested for example by Brooker and Ireland ($K_o=0.95 - \sin\phi'$), and the modified Jaky Equation ($0.9 \times (1 - \sin\phi')$) based on $\phi'=26^\circ$ suggested by Ambrosie (1984).

7.3.3 Values of λ and κ

Values of λ_1, λ_2, κ_1 and κ_2 have been reported in Chapter 5. As mentioned earlier, the λ_1-values ranged from 0.532 to 0.726 with an average of 0.621 and a standard deviation of 0.055. The λ_2-values during triaxial consolidation ranged from 0.202 to 0.246 with an average of 0.226 and a standard deviation of 0.017. Values of λ_1 and λ_2 have comparatively close coefficients of variation[6] (8.9% for λ_1 and 7.5% for λ_2). However, the

---

[6] Coefficient of variation = (standard deviation / mean) x 100%

mean λ_2-value is about one third as large as that of λ_1. The reason for this difference is unclear. One possible explanation is that the load ratios were in fact different during slurry and triaxial consolidation (1.38 and 1.15 respectively), thus causing the difference in λ_1-values. It would normally be expected however that changes in load ratio would move the consolidation line in $\ln(\sigma'_v)$,e space, but would not change its slope (Bjerrum(1967), Leonards and Altschaeffl(1964)).

The slopes of the reload lines κ_1 in the triaxial tests were determined and were compared with that of the swelling lines κ_2 after the maximum vertical load had been applied. Values of κ_1 and κ_2 are presented in Table 4. The κ_1-values ranged from 0.072 to 0.168 with an average of 0.103 and a standard deviation of 0.030. The κ_2-values were the least variable among all the λ and κ values reported. An average of 0.0476 and a standard deviation of 0.0076 were obtained for the κ_2-values. The average κ_1-values was about 2.2 times larger than that of the κ_2-values. This difference was probably due to two reasons. Firstly the load ratio used during the reload period was 1.15. During the swelling period, the load ratio adopted was 0.5 due to time limitations discussed before. This might have caused the difference in the κ_1 and κ_2 values. Secondly it has been known (Leonards and Altschaeffl(1964)) that within a fixed range of vertical pressures, the slopes of the swelling line and the reload line are not the same, and that the reload line is always steeper than the swelling line. This is probably the major reason for κ_1-values being larger than κ_2-values in this investigation.

During triaxial consolidation, the λ_2/κ_1 ratio measured was about 2.2 which at first sight might appear to be low. However, Li(1983) reported the same ratio to be about 2.1 for remoulded Winnipeg clay, and Graham et al(1983a) reported the values of about 2.2 for natural Winnipeg clay. Some structured natural clays may have λ/κ ratios in the order of 6 or more (Rutledge(1944), Holtz and Kovacs(1981)). Quigley and Thompson(1966) reported that the λ/κ ratio dropped considerably, when comparing Leda clay in its natural state and remoulded state. They therefore concluded that natural Leda clay was structured and sensitive. Illite was not tested in its natural state in this study. No assessment could therefore be made on whether the clay is structured or sensitive in its natural state.

7.3.4 Observed Yield Stress and the Cylinder Preconsolidation Stress

The yield stresses observed during triaxial consolidation have been compared with the known preconsolidation pressure of 70kPa experienced by the clay during slurry consolidation. Graphs of different criteria which were used to define the yield points are presented in Figures 5.6 to 5.26. Yield stresses were identified using bilinear plotting techniques described by Graham et al(1982). The average yield stress obtained for each sample based on different yield criteria is presented in Table 5. These average yield stresses were compared with the preconsolidation stress of 70kPa and an average percentage difference of only 3.3% was calculated. (Li(1983) reported an average percentage difference of 4.4% for remoulded Winnipeg clay.) The average yield stresses in the present study were higher than 70kPa for all samples except for T712 in which the average was 1% lower.

In this latter test (T712) the yield stress could be determined only from the W,LSSV criterion. At the beginning of triaxial consolidation, the adopted K ratio was 0.50 for this sample, but during the first five load increments, the K ratio was adjusted successively towards the final value of 0.46. Due to these changes in stress ratio, interpretation of yield stress was difficult. It was not possible to distinguish whether observed changes in stress-strain behaviour were associated with yielding of the clay, or were simply due to the applied changes of stress ratio (Lew(1981)). The same difficulty in determining yield points was also encountered in some other samples tested at the beginning of the program (for example T702 and T706). Samples which experienced little or no change in effective stress ratios around yielding produced yield stresses that could be determined from almost every criterion without difficulty.

7.3.5 Elastic Parameters

Elastic parameters K_{eq} and G_{eq} and their normalized values K_{eq}/σ'_{cyl} and G_{eq}/σ'_{cyl} have been briefly discussed in section 5.3.7. The values are presented in Table 4. Wroth et al(1979) reported G/σ'_{vc} values of many clays to be about 11. This is higher than the value of about 4.5 reported by Graham et al(1983a) for natural Winnipeg clay. For remoulded Winnipeg clay, Li(1983) reported G/σ'_{vc} values ranging from 4.3 to 38.6 with an average of 13.6. In the present investigation, the values ranged from 5.6 to 18.4 with an average of 13.2. Due to the much lower G/σ'_{vc} values reported by Graham et al(1983a), there was initially some speculation that the testing procedures adopted at the University of Manitoba had introduced disturbance to the samples. The procedures used by the author were the same as those of Li(1983) and Graham et al(1983a), and the G/σ'_{vc} values measured in this investigation are similar to the average value reviewed by Wroth et al(1979). It can therefore be concluded that the low value of G/σ'_{vc} for natural Winnipeg clay results from the particle structure of the clay itself and not from any faults in testing procedures.

7.4 UNLOADING BEHAVIOUR

7.4.1 Unloading of Consolidation Shear Stress

All samples except the two control samples were subjected to total stress unloading at the end of consolidation and backpressuring. Before unloading, all samples were under an effective vertical stress of 80kPa and an effective horizontal stress of about 42kPa depending on the K ratio adopted. Furthermore, the samples were under a backpressure of 500kPa, except for T718 in which the backpressure was applied at 400kPa to control a leakage of cell fluid at higher pressure. The stress paths of the samples during unloading in p',q space are presented in Figures 7.2 to 7.4.

All samples were allowed to sit for a standardized period of 4 days at the final stress level before unloading. They were then backpressured again for a period of 24 hours in preparation for shearing. During unloading, small porewater pressure changes were also often observed after closing the drainage lead to simulate the field undrained unloading procedures. The porewater pressure sometimes increased or decreased by a maximum of about 2.5kPa at this stage. It was initially thought that closing of the valve introduced a volume change in the system, causing the porewater pressure to vary. Since the changes observed were not systematic, porewater pressure variations are therefore thought to be associated with the fluctuation of cell pressures and backpressures during the overnight period before unloading. If the cell pressure and the porewater pressure changed by different amounts, the effective stresses would differ from their designated values. The procedures adopted were to adjust the cell pressure and the porewater pressure to their designated values before unloading. A period of about 1 hour was then allowed for porewater pressure equilibrium to be reached. However Figures 7.2 to 7.4 clearly show that porewater pressure equilibrium was not achieved in some of the samples. This caused the initial sections of the shear unloading stress paths to shift slightly laterally. The unloading stress paths then exhibited almost straight and almost vertical behaviour. This indicates that the samples at this stage were virtually elastic, isotropic and saturated. During the last decrement of unloading, the stress paths of some samples (T704, T706 and T710) shifted to the right. This was possibly due to equipment problems, rather than to fundamental behaviour of the clay. However it contrasts with the behaviour of normally consolidated samples measured by Ambrosie(1984).

7.4.2 Unloading of Consolidation Cell Pressure

All samples were subjected to isotropic unloading following the previously described unloading of the consolidation shear stress. The stress paths of the samples during isotropic unloading are also presented in Figures 7.2 to 7.4. However it is difficult to distinguish the behaviour exhibited by the samples during this stage and the dwell period. During isotropic unloading, the porewater pressure usually decreased by about the same amount (97%-100%) as the total stress change. This caused the effective octahedral stress p' to stay approximately constant between load decrements. Although the overall drops in p' were usually observed from the beginning to the end of isotropic unloading, the differences were small, usually in the order of 1 to 3.5kPa. As was described earlier, T710 experienced some leakage past the drainage valve during testing. The leak resulted in an uncharacteristically large reduction of porewater pressure during the isotropic unloading phase of this test. This caused a much larger decrease in p' (about 30kPa) during the unloading stage as shown in Figure 7.3a.

Figure 7.5 shows the porewater pressure response of three samples (T708, T714 and T720) during isotropic unloading. The behaviour of these three samples were typical among all the samples subjected to unloading. The following observations can be made from Figure 7.5. (1) All three samples followed almost the same stress path during unloading. (2) The unloading stress paths were straight until the porewater pressures dropped to zero. The stress paths then deviated slightly from the straight line relationship. This was systematically observed from all samples. One possible reason to explain this behaviour is that the transducers were non-linear in tension.

7.5 BEHAVIOUR OF SAMPLES DURING DWELL PERIOD

All samples except the control samples were subjected to periods of low isotropic stress (5kPa) after unloading. This was done to model the undrained storage of the samples on-ship or in the laboratory before testing. The selected durations of the dwell periods were 15 minutes, 1 day and 1 week. The background leading to the selection of these three periods was discussed in Chapter 3. Figures 7.2 to 7.4 show the stress paths in p',q space during this dwell period. The drop in p' values at this stage depended on the duration of the periods. For samples subjected to 15-minute and 1-day dwell periods, the drops in p' values were small, ranging from 0 to 3.2kPa. The drop in p' for samples subjected to 1-week dwell period was more significant, ranging from 7.4kPa to 21.2kPa. Sample T710 is again excluded from the discussion because of the leakage problem encountered.

Figures 7.6a and 7.6b show in logarithmic and arithmetic scales respectively the porewater pressure behaviour of the samples with respect to time during the 1-week dwell periods. Figure 7.6a shows that initially the negative porewater pressure stayed almost constant at a negative value of about -45kPa to -51kPa, followed by a sudden increase at times ranging from 12 hours to 2 days after unloading. The reason for this sudden change of porewater pressure behaviour is unclear. It could possibly be due to a sudden breakdown of the clay structure, or an equipment problem such as valve leakage, or leakage past sealing rings, or diffusion through the membranes. Towards the ends of the 1-week dwell periods, samples T708 and T720 showed some tendency to reach a constant value of negative porewater pressure. However sample T714 still showed a linear relationship between porewater pressure and elapsed time. Further research into the behaviour of samples during the dwell period is required.

Kirkpatrick (1982) reported that the residual porewater pressure U_R of his unconsolidated samples dropped to 45% of the initial residual porewater pressure U_{Ri} after 5 hours of unloading. At sample age of 50 days, the ratio U_R/U_{Ri} dropped to only 25%. His results appear to be very much different from those obtained in this investigation. However the conditions under which the "samples" were stored and tested were different in the two studies. Kirkpatrick's samples were stored in a wrapped and sealed form and could reasonably experience some small expansive straining that would have significant effect on the porewater pressures. The drainage condition was complex, possibly a combination of both drained and undrained control (Chapter 3). The "samples" in the present investigation were under undrained conditions during the dwell period, modelling those samples which are stored in Shelby tubes, and extruded just before testing. Since the testing and drainage conditions in the two investigations were not the same, it is perhaps not surprising that the drop in residual porewater pressures were significantly different.

The problem of dissolved gases coming out of solution from the pore fluid of the samples upon stress release was addressed by many investigators (for example Okumura(1971) and Procter(1976)). In this investigation, bubbles were flushed out only from sample T708 at the end of the dwell period. For the overconsolidated samples tested, gas releasing problem was generally not encountered. This may be due to the relatively low level of unloading. The degree of saturation of the samples before shearing was considered to be satisfactory (B values in Table 6). For samples which are subjected to higher unloading stress level, gas releasing behaviour could probably be anticipated. Further research in this area is required.

7.6 BASIC SOIL PROPERTIES AND GENERAL DISCUSSIONS ON MOISTURE CONTENTS

7.6.1 Basic Soil Properties

Classification tests including Atterberg limits, specific gravity and hydrometer analysis for grain size distribution were performed on the illitic clay used in this investigation. These tests were conducted on trimmings from triaxial samples after undrained shearing. The average index properties are compared with those of Grundite (Wu et al(1983)) in Table 2. Relatively good agreement is obtained between the two sets of measurements. In the present study, the values of plasticity index and activity were 31.5% and 0.52 respectively. The corresponding values reported by Wu et al(1983) were 28.3% and 0.53. Atterberg limits tests were performed on eight of the eleven samples tested. Table 7 shows that no major difference in plasticity existed among the samples (from 29.9% to 35.4% with an average of 32.2% and a standard deviation of 1.9%).

7.6.2 Moisture Contents at Different Stages During Testing

The moisture contents at different stages during testing are also presented in Table 7. The five sets of moisture contents were obtained as follows:

1. At the slurry stage before cylinder consolidation.
2. At the end of cylinder consolidation, that is, the beginning of triaxial testing. Moisture contents were obtained from trimmings during the building-in process.
3. After triaxial consolidation. These were obtained by calculation knowing the initial moisture contents and the volume changes during consolidation.
4. Before shearing (after reconsolidation). Moisture contents at this stage were again calculated.
5. Trimmings from failed samples were determined for moisture contents after the completion of undrained shearing.

The difference in moisture contents between "after triaxial consolidation" and "before shearing" in Table 7 indicates the moisture content change during unloading, dwell and reconsolidation. The samples were under undrained conditions during both the unloading and dwell stages, so the difference in moisture contents was associated only with the reconsolidation stage. The changes in axial and volume strains during this reconsolidation period are presented in more detail in Table 6. The changes in linear and volume strains were clearly affected by the reconsolidation procedures. In general, these changes were small, supporting previous the discussions (section 7.5) that no significant loss of effective stress occurred in most samples during the dwell period. Samples in Group 2 experienced 0.16% to 0.31% of volume expansion because p' was decreased from about 55kPa to 48kPa. For samples in Group 3, the p' values increased from about 55kPa to 80kPa. This was accompanied by volume decrease ranging from 0.96% to 1.32%. Since the increase in p' in this case was greater than the decrease (absolute value) in p' in Group 2, the volume decrease was larger than the volume increase experienced by Group 2 samples. The bulk modulus ($K=\Delta p'/\Delta v$) can be calculated for both groups. The values obtained were 3.5MPa for Group 2 samples (unloading), and 2.4MPa for Group 3 samples (loading). Virtually no volume change (+0.04% to -0.07%) was observed for samples in Group 4 during reconsolidation, since the samples were reconsolidated to the original horizontal and vertical stresses before unloading (that is no change in p'). This indicates that the test procedures had not introduced mechanical disturbance to the samples.

The final moisture contents of the samples were determined from the trimmings after shearing. This was checked with the calculated results at the stage before shearing (Table 7). Since the samples were sheared undrained, the moisture contents before and after shearing should be the same. Table 7 shows that these two sets of values are compatible in most cases. The percentage differences between measured and calculated moisture contents (absolute value) ranged from 0% to 1.2% if T712 is neglected. This indicates that using burettes to measure volume change is reasonably reliable even though the samples were subjected to complicated stress-strain variations over a relatively long period of testing. The time required for each sample between building-in and building-out from the triaxial cell was about 3 to 4 weeks depending on the duration of the dwell period. The lower measured moisture content in sample T712 compared with the corresponding calculated value again supports the view that leakage had developed during shearing.

7.6.3 Moisture Content Profile Across Failed Samples

There was initially some concern regarding the accuracy of determining the moisture contents using the traditional method, namely oven drying wet trimmings, and also in the variations of moisture content along the length of the samples. Figure 7.7 shows the moisture content profiles across three randomly selected samples. Each failed sample was cut into six transverse slices along its height. Two moisture determinations were then performed on each slice. The following observations can be made from Figure 7.7.

1. The difference between the two moisture contents determined from each slice was generally less than 0.8%, and averaged 0.4%.
2. The moisture content difference along the length of the sample was generally less than 1.5%.
3. There is a tendency for the moisture contents to be slightly lower in the middle of the sample compared with the top and the bottom. This is however contrary to suggestions by Bishop(1961) that moisture contents varied with distance along the axis of the sample during testing, with the moisture content in the middle higher than that at the bottom and the top of the sample.

7.7 UNDRAINED SHEARING BEHAVIOUR

7.7.1 Normally Consolidated and Overconsolidated Failure Envelopes

The tests conducted in this investigation permit an evaluation of the overconsolidated Coulomb-Mohr rupture envelope of the clay. When these are taken in conjunction with the results obtained by Ambrosie(1984), both the normally consolidated and the overconsolidated rupture envelopes of the illitic clay at a preconsolidation pressure of 160kPa can be determined. The envelopes are presented in Figure 7.8. Although the yield deviator stress defined in Chapter 6 was used for comparison of the failure conditions, maximum deviator stresses have been used to determine the rupture envelopes. Ambrosie(1984) reported a cohesion of 0kPa and an effective friction angle of 26° for the normally consolidated samples he tested. The overconsolidated envelope with a cohesion of 16kPa and a friction angle of 18° was defined by linear regression from the eleven samples tested in the present study. A relatively high correlation coefficient of 0.988 was obtained. It is interesting to note that the data points from samples T710 and T712 lie on the normally consolidated rupture envelope. These two samples experienced sudden drops in porewater pressure at the beginning of testing, which led to shifting of the stress paths to the right. These were reported in Chapter 6. The author suggests that since the normally consolidated and overconsolidated envelopes are in close proximity in this region, it is only by coincidence that these two points lie on the normally consolidated envelope. It should be pointed out that the strength parameters suggested by Ambrosie(1984) are very close to those suggested by Wu at al(1983) for Grundite (c'=0kPa, ϕ'=25°).

7.7.2 <u>Influence of Duration of Dwell Period on Undrained Shear Strength</u>

The effects of two parameters, namely duration of dwell period and reconsolidation procedures, on the undrained shear strength of clay samples were studied in this investigation. The results will be discussed in the following sections. Three samples were tested for each of three reconsolidation procedures with different durations of dwell period. This was mentioned in section 7.5. The stress paths during undrained shearing in p',q space for all nine samples in the three reconsolidation groups are presented in Figures 6.13 to 6.15. The behaviour of the samples during shearing was discussed in sections 6.2 and 6.3. The undrained shear test results are presented in Table 6. In order to reduce confusion, the codes used to identify the "insitu soils" and the "samples" defined in section 6.1 will again be used in this chapter.

Table 6 shows that the q_y values for samples in Group 2 (0.6 x σ'_{1c} CIU) were very close, with T706 (1-day dwell) the highest and T708 (1-week dwell) the lowest. Sample T706 again exhibited the highest values in q_{max} among samples in Group 2. The q_{max} values for the other two samples (T704 and T706) were virtually the same. Since the preconsolidation pressures for all three samples were approximately 160kPa, the values of q_y/σ'_{vc} and q_{max}/σ'_{vc} follow the corresponding trend exhibited by the q_y and q_{max} values respectively.

Figure 7.8 shows that the q_{max} values of the three samples in Group 2 lie very close to the overconsolidated failure envelope, and are within the range of acceptable experimental scatter according to the author's view. In addition, Figure 6.13 shows that the stress paths of these samples are in close proximity. It can therefore be concluded that the duration of the undrained dwell period did not affect either the shearing behaviour or the undrained strength envelope for the samples in Group 2.

Sample T710 (1-day dwell) in Group 3 (1.0 x σ'_{1c} CIU) showed the largest values of both q_y and q_{max} in the group. Sample T712 (1-week dwell) exhibited the lowest q_y and q_{max} values. The coefficients of variation for the samples in this group were 11.9% for q_y and 11.6% for q_{max}. The numerical values at first sight may suggest that no relationship between undrained strength and dwell period can be deduced for this group of samples. The stress paths shown in Figure 6.14 however suggest that some pattern can be observed. This will be discussed in the remainder of this paragraph. Problems regarding porewater pressure disequilibrium at the beginning of undrained shearing in tests T710 and T712 were discussed in the previous chapter. Furthermore the leakage problem of sample T712 during shearing was also mentioned. Both of these events caused the stress paths to shift to the right in p',q space. Since these two samples were subjected to increases in effective octahedral stress corresponding to (1) leakage and (2) a decrease in initial porewater pressure, the maximum deviator stresses were therefore higher compared with the maximum deviator stress of sample T714. Figure 7.8 shows that the maximum deviator stresses of the samples in this group are located within an acceptable range of experimental scatter from the average overconsolidated rupture envelope. The lateral shifting of the stress paths was in fact helpful in permitting determination of the rupture envelope, since a wider range of data points was made available in p',q space. It is perhaps suprising and encouraging to know that tests which have "gone wrong" can produce considerable amount of constructive information.

Disregarding for the moment the irregularities of the stress paths of T710 and T712 discussed above, Figure 6.14 showed that all three stress paths are approximately parallel to each other. The post peak behaviour of samples T710 and T714 are very similar. When considered in conjunction with the maximum p',q-values lying close to a well defined rupture envelope in Figure 7.8, it can also be concluded that the duration of the dwell period did not affect the shearing behaviour and the undrained strength envelope of the samples in Group 3.

The Group 4 samples were consolidated to the original stress levels experienced before unloading (1.0 x σ'_{1c} CK_oU). Table 6 shows that all three samples have close q_y values. For practical purposes, they can be assumed equal. The q_{max} values are also very close, and lie virtually on the rupture envelope. Figure 6.13 shows that the stress paths of these samples during shearing are bunched together. Therefore it can also be concluded that the duration of the dwell period had no effect on both the undrained shear strength and the shear behaviour for this group of samples.

The shear behaviour of all nine samples subjected to three different reconsolidation procedures has been discussed in this section. Conclusions can be drawn that under undrained conditions, the undrained shear strength and the shear behaviour will be unaffected by the dwell period, but as will be shown later, they depend on the stress conditions during reconsolidation. This conclusion can be easily misunderstood, and should therefore be examined carefully. Porewater pressure increase (decreases in p') were observed during the dwell periods as reported in section 7.5. The reductions were small for samples subjected to 15-minute and 1-day dwell periods, and more significant for those subjected to dwell periods of 1 week. However even with these different amounts of reduction in effective stress, the same undrained strengths and shear behaviour were obtained from samples that were subjected to the same reconsolidation procedures. It was therefore concluded that under identical reconsolidation procedures, the strengths and shear behaviour of samples were not affected by the duration of the dwell period. This should not be confused with the conclusions suggested by Skempton and Sowa (1963), and Adams and Radhakrishna (1970) that for samples with no loss of suction during unloading, the undrained strengths of the "insitu soils" and the "samples" would be identical. In these two studies, the "samples" had not undergone reduction in effective stress and reconsolidation procedures were not performed. Kirkpatrick (1982) suggested that under the same reconsolidation procedures, sample ages of up to 1 month had no effect on undrained strength. This agrees with the results obtained in the present study.

7.7.3 Usefulness of Reconsolidation Procedures in Recovering "Insitu" Strength

Two control samples were tested to model the shear behaviour of the "insitu soils". The results were compared with those of the other nine samples which had undergone unloading. The usefulness of each reconsolidation procedure in recovering the insitu strength could in principle therefore be evaluated.

Before evaluating the reconsolidation procedures, the shear behaviour of the two control samples will first be discussed. Figure 6.12 shows the stress paths of these two samples. Sample T702 encountered the same initial porewater pressure drop described for tests T710 and T712 previously. The drop caused the stress path of this sample to shift to the right. Although there is a significant difference in both the q_y and the q_{max} values between these two samples, Figure 7.8 shows that they lie on the same rupture envelope. This indicates that both samples exhibited similar behaviour under shearing. Due to the porewater pressure irregularities of sample T702, only sample T722 will be used in the following sections to evaluate the usefulness of the reconsolidation procedures.

Figure 7.8 shows that samples from both Group 2 and Group 4 reconsolidation procedures could predict the insitu undrained shear strength with adequate accuracy. Isotropic reconsolidation to insitu vertical stress (Group 3) overestimated the undrained strength by about 12% in these overconsolidated samples (OCR=2). (In the parallel series of normally consolidated samples tested by Ambrosie(1984), the equivalent increase was 19%.)

The vertical strain at yield was larger in all the offloaded samples than in the control samples. The strains for the two control samples at yield were 0.65% and 0.75% respectively. The corresponding average strains for Groups 2, 3 and 4 were 1.38%, 1.63% and 1.06% respectively. Table 6 shows that the failure strains can be grouped according to the reconsolidation procedure. The values were in general consistent among the three samples in each group.

Values of the secant modulus E_{50} and the relative stiffness $E_{50}/0.5q_y$ are presented in Table 6. Sample T722 showed high E_{50} and $E_{50}/0.5q_y$ values compared with the other control sample (T702). The reason for this significant difference is unclear. In any case the secant moduli obtained from the "samples" were lower than those of the control samples. Group 4 samples underestimated the E_{50} values by a greater amount (36%) compared with samples from Group 2 and Group 3 (9.4% and 14% respectively). Kirkpatrick(1982) reported the reconsolidated "samples" (to insitu stresses) underestimated the secant modulus of the "insitu soils" by about 50% for his overconsolidated illite samples.

Based upon the results obtained in this study, conclusions can be drawn that both Group 2 and Group 4 reconsolidation procedures can adequately predict the insitu shear strength. Both methods however overestimated the vertical strain at failure and underestimated the secant modulus.

Kirkpatrick(1982) concluded that K_o reconsolidation to insitu stresses was successful in recovering the insitu strength. He also reported that if the moisture contents of the samples were unaltered, age had no effect on consolidated undrained behaviour. This agrees with the results obtained in the present study.

7.7.4 Porewater Pressure Generation

The results of porewater pressure generation were presented in section 6.4. It was pointed out that the A_f-values can be grouped according to the reconsolidation procedures (Table 6). Group 4 samples adequately modelled the A_f -values of both control samples at yield (0.19 and 0.20 respectively). Samples in Group 2 and Group 3 however overestimated the A_f -values by about 30% and 75% respectively. Furthermore, samples which had been allowed 1 week for the dwell period (T708, T714 and T720) showed A_f -values from 10% to 44% higher than the other two samples (15-minute and 1-day dwell periods) in the corresponding groups. Kirkpatrick(1982) reported that A_f-values decreased with sample age in his remoulded unconsolidated samples. For illite with an overconsolidation ratio of 2.67, he reported A_f-values of 0.15 and 0.05 at samples ages of 1 day and 7 days respectively. However for the samples reconsolidated to insitu stresses he tested, Kirkpatrick concluded that the A_f-value at failure of the "samples" were about two times larger than the A_f of the "insitu soils". This indicates that the unloading process has caused particle reorientation towards a less overconsolidated configuration, leading to a larger A_f value for "samples" compared with "insitu soils". This view is also supported by Graham and Au(1984) for the "Freeze-Thaw", "Softened" and "Undisturbed" Winnipeg clay they tested.

Porewater pressure behaviour during shearing was also examined in terms of $\Delta u/\sigma'_{vc}$ vs $\Delta p/\sigma'_{vc}$ (Figs. 6.16-6.19) in this study. The slopes m of the linear sections of these graphs are summarized in Table 6. Except for samples T702 and T708, all m values are higher than 1.0. The average m values were 1.04, 1.12, 1.39 and 1.10 for samples in Groups 1, 2, 3 and 4 respectively. Isotropic clay in the elastic range would give m=1.0, that is $\Delta u=\Delta p$. The measured m values greater than unity for the remoulded illitic clay indicates that the clay was lightly anisotropic in most cases, and with higher horizontal stiffness than vertical stiffness (Graham and Houlsby(1983)). It is interesting to note that the remoulded reconsolidated samples were under one-dimensional stress conditions during both slurry and triaxial consolidations until unloading. The samples appeared to be virtually isotropic during unloading. This is supported by the almost vertical unloading stress paths discussed in section 7.4.1, and the m=1.04 value for the control samples which had not undergone unloading. However after reconsolidation, the samples became lightly anisotropic as indicated by the m values. In other words, unloading modified the original clay structure in a way that produces an apparently anisotropic behaviour in subsequent loading. Considering the m values measured, Groups 2 and 4 reconsolidation procedures again better modelled the insitu behaviour than Group 3.

7.7.5 Strain Rate Effect

It has been shown that large variations in undrained shear strength can be caused by different straining rates during shearing (Bjerrum et al(1972), Graham et al(1983b)). Results for the strain rate parameters $\rho_{0.1}$ for the remoulded illitic clay have been presented in section 6.6. The $\rho_{0.1}$ parameter ranged from 3.8% to 10.6% (Fig. 6.20 and Table 6). Reconsolidation procedures and the duration of the dwell period did not seem in this case to have any effect on the $\rho_{0.1}$-values. Table 6 also shows the vertical strains at the start and at the end of the relaxation test ($\varepsilon_{\rho s}$ and $\varepsilon_{\rho e}$) for each sample. The values show that the total vertical straining of the samples during the relaxation tests was between 0.1% to

0.2%. Li(1983) also reported low $\rho_{0.1}$-values (5.4% to 8.2%) for remoulded Winnipeg clay. Both sets of values are rather lower than the range of about 10% to 15% for many natural clays reported by Graham et al(1983b). One possible reason is that the strain rate effect decreases with increasing vertical strain (Brown(1969)). Since only a small extent of strain softening behaviour was observed in samples in this investigation compared with undisturbed Winnipeg clay samples (Lew(1981)), conducting the relaxation tests at 3% beyond the yield strain was not enough to cause the difference in $\rho_{0.1}$-values compared with the range reported by Graham et al(1983b). Crawford(1961), Lo and Morin(1972) and Sangrey(1972) have reported that the cemented and structured strength envelopes of some natural clays were time and strain rate dependent. Another possible reason to explain the difference in $\rho_{0.1}$-values is that the interparticle cementations and the structured bonds of natural clays are destroyed by remoulding, causing remoulded clays to have lower $\rho_{0.1}$-values. Relatively lower strain rate effects were measured for some remoulded clays (Richardson and Whitman(1963), Perloff and Osterberg(1963)), and this perhaps accounts for the relatively low attention to the whole subject of strain rate effects in most soils testing.

Chapter VIII

CONCLUSIONS AND SUGGESTIONS FOR FURTHER RESEARCH

8.1 CONCLUSIONS

Based on the study presented in this thesis on the testing of illite from Grundy County, Illinois, the following conclusions can be drawn.

1. X-ray diffraction tests indicated that the major minerals present in the clay were quartz, illite and kaolinite, with proportion (by occurrence) of illite to kaolinite more than 5:1. The index properties were close to those of Grundite reported by Wu et al (1983).
2. Under identical loading schedules, the λ_1-values for cylinder consolidation ranged from 0.532 to 0.726 with a coefficient of variation of 8.9%.
3. The mean λ_2-value (0.226) for triaxial consolidation was about one-third as large as the mean λ_1-value (0.621) for cylinder consolidation.
4. During triaxial consolidation, the mean κ_1-value (0.103) for reloading was about 2.2 times larger than the mean κ_2-value (0.0476) for unloading.
5. The λ_2/κ_1 ratio measured was 2.2.
6. For the small range of $K=\sigma_3'/\sigma_1'$ values tested, there was a straight line relationship between $\log(\varepsilon_{1c}/\varepsilon_{3c})$ and K. Analysis of the data showed that the K_o value was 0.49.
7. The average one-dimensional yield stress measured during triaxial consolidation using bilinear plotting techniques was on average

only 2.2kPa higher than the previous highest axial consolidation pressure of 70kPa.

8. The G/σ'_{vc} values measured during triaxial consolidation ranged from 5.6 to 18.4 with an average of 13.2. The final vertical consolidation stress was 80kPa with an overconsolidation ratio of 2.0.
9. The stress paths of the samples under shear unloading were almost straight and almost vertical. This indicates that the samples at this stage were virtually elastic, isotropic and saturated.
10. During the period of isotropic unloading, the effective octahedral stress p' generally stayed constant between load decrements. The overall drops in this stage were small, usually in the order of 1 to 3.5kPa.
11. Samples subjected to 15-minute and 1-day dwell periods experienced small drops in p' (0-3.2kPa). The drops in p' for the 1-week-dwell samples were larger (7.4-21.2kPa).
12. The overconsolidated strength parameters were $c'=16kPa$, $\phi'=18^\circ$ for a preconsolidation pressure of 160kPa and an overconsolidation ratio of 2.0. (Ambrosie(1984) reported normally consolidated parameters of $c'=0kPa$ and $\phi'=26^\circ$ for illite.)
13. If identical reconsolidation procedures were used, the strengths and shear behaviour of "samples" which had undergone undrained unloading were unaffected by the duration of the dwell period.
14. Anisotropic reconsolidation to insitu stresses was successful in reproducing insitu shear strengths and A_f-values. Isotropic reconsolidation to $0.6 \times \sigma'_{1c}$ was also successful in reproducing insitu shear strengths, A_f-values were however overestimated. Isotropic reconsolidation to $1.0 \times \sigma'_{1c}$ overestimated both the insitu

strengths (by 12%) and the A_f-values. All three reconsolidation procedures overestimated the faliure strains and underestimated the moduli values.

15. The unloading process caused particle reorientation that led to larger A_f-values for "samples" compared with "insitu soils". Unloading also produced an apparently anisotropic behaviour in subsequent loading.
16. The strain rate parameter $\rho_{0.1}$ varied from 3.8% to 10.6%.
17. The moisture content difference across the whole sample was generally less than 1.5%. There is a tendency for the moisture contents to be slightly lower in the middle of the sample compared with the top and the bottom.
18. Using burettes for volume change measurements was relatively reliable even though the samples were subjected to complicated stress-strain variations over a quite long period of testing.

8.2 SUGGESTIONS FOR FURTHER RESEARCH

1. Further work on improving the moisture content consistency for cylinder consolidation is urgently required. Loading schedule could be controlled by strain to improve the consistency. Larger cylinders which would produce more than one sample at a time could also be used.
2. In order to model the real samples which are often extruded from samples tubes after sampling, and stored in a waxed and sealed form, drained conditions could be permitted during the dwell period. Measurement of porewater pressures should also be allowed. This can be achieved by eliminating the circumferential filter

strips, measuring porewater pressure using a cell-base pressure transducer as done in this study, and allowing drainage through the top cap.

3. Research should be conducted on samples subjected to higher level of stress release. The gas-releasing behaviour and the degree of saturation of the samples should be carefully examined.
4. A better control of the effective stresses should be aimed at during the back pressuring stage. This is to eliminate the sudden porewater pressure fluctuation at the beginning of unloading and shearing.
5. A detailed study of the shape of the yield envelope of illite should be conducted.
6. Trials of other sealing constituents for the modified cell-top should be continued.
7. The value of K_o should be measured using strain gauges connected to a servo mechanism that also controls the cell pressure.

BIBLIOGRAPHY

Adams,J.I. and Radhakrishna,H.S. 1971. "Loss of Strength Due to Sampling in a Glacial Lake Deposit". Sampling of Soil and Rock, ASTM STP 483, 109-120.

Ambrosie,A.W. 1984. "Effects of Stress-Release Disturbance on the Shear Behaviour of Simulated Offshore Normally Consolidated Clay Samples". (In Preparation).

Au,V.C.S. 1982. "Rate Effects and Low Stress-Strength of Winnipeg Clay". M.Sc. Thesis, University of Manitoba, Winnipeg, Manitoba.

Bishop,A.W. and Bjerrum,L. 1960. "The Relevance of Triaxial Test to the Solution of Stability Problems". Proc. ASCE Spec. Conf. on Shear Strength of Cohesive Soils. Boulder, Calorado, USA, 437-501.

Bishop,A.W. 1961. "Soil Properties and Their Measurement". Proc. 5th Int. Conf. on Soil Mech. and Found. Eng., Paris, Vol.III, 87-93.

Bishop,A.W. and Henkel,D.J. 1962. "The Measurement of Soil Properties in the Triaxial Test". Edward Arnold, London, 2nd edition.

Bjerrum,L., Clausen,C.J.F. and Duncan,J.M. 1972. "Stability of Flexible Structures". Fifth European Conf. on Soil Mech. and Found. Eng., Madrid. General Report, Session IIIa.

Bjerrum,L. 1967. "Engineering Geology of Norwegian Normally Consolidated Marine Clays as Related to Settlements of Buildings". Geotechnique 17, No.2, 81-118.

Bjerrum,L. 1973. "Problems of Soil Mechanics and Construction of Saturated clays and Structurally Unstable Soils". State-of-the-Art report at Session 4, Proc. 8th Int. Conf. on Soil Mech. and Found. Eng., Moscow, vol.3, 111-159.

Bozozuk,M. 1971. "Effect of Sampling, Size, and Storage on Test Results for Marine Clay". Sampling of Soil and Rock, ASTM STP 483, 121-131.

Brooker,E.W. and Ireland,H.O. 1965. "Earth Pressures At Rest Related to Stress History". Can. Geotech. J., Vol.2, No.1, 1-15.

Brown,J.D. 1969. "Measurement of the Effect of Strain Rate on Undrained Shear Resistance". Norwegian Geotech. Inst., Oslo, Norway, Internal Report, F83-4.

Cassagrande,A. and Rutledge,P.C. 1947. Co-operative Triaxial Shear Research, Waterways Experiment Station, Vicksbura, Mississippi, USA.

Crawford,C.B. 1961. "The Influence of Strain on Shear Resistance of Sensitive Clay". American Society for Testing and Materials, Proceedings, Vol.61, 1250-1276.

Crooks,J.H.A. 1973. "Laborotory Studies of Belfast Estuarine Deposits". Ph.D. Thesis, Queen's University, Belfast, Northern Ireland.

Davis,E.H. and Poulos,H.G. 1967. "Laboratory Investigation of the Effects of Sampling". Civ. Eng. Transactions, Instit. of Engrs., Australia, Vol.CE.9, No.1, 86-94.

De Ruiter,J. and Richards,A.F. 1983. "Marine Geotechnical Investigations, A Mature Technology". Proc. of the Conf. on Geotechnical Practice in Offshore Engineering, Austin, Texas, 1-24.

Gibson,R.E. and Dowse,B.E.W. 1981. "The Influence of Geotechnical Engineering on the Evolution of Offshore Structures in the North Sea". Can. Geotech. J., 18, No.2, 171-178.

Graham,J. 1974. "Laboratory Studies of Sensitive Clay from Lyndhurst, Ontario". Civil Engineering Research Report CE74-2, Royal Military College, Kingston, Ontario.

Graham,J., Pinkeny,R.B., Lew,K.V. and Trainor,P.G.S. 1982. "On Curve-Fitting and Laboratory Data". Can. Ceotech. J., Vol.18, No.2, 201-205.

Graham,J., Noonan,M.L. and Lew,K.V. 1983a. "Yield States Stress-Strain Relationships in a Natural Plastic Clay". Can. Geotech. J., Vol.20, No.3, 502-516

Graham,J., Crooks,J.H.A. and Bell,A.L. 1983b. "Time Effects on the Stress-Strain Behaviour of Natural Soft Clays". Geotechnique 33, No.3, 327-340.

Graham,J. and Houlsby,G.T. 1983c. "Anisotropic Elasticity of a Natural Clay". Geotechnique 33, No.2, 165-180.

Graham,J. and Au,V.C.S. 1984. "Influence of Freeze-Thaw and Softening on a Natural Clay at Low Stresses". (In Preparation)

Hambly,E.C. 1972. "Plane Strain Behaviour of Remoulded Normally Consolidated Kaolin". Geotechnique 22, No.2, 301-317.

Holtz,R.D. and Kovacs,W.D. 1981. "An Introduction to Geotechnical Engineering". Prentice-Hall.

Hvorslev,M.J. 1949. "Subsurface Exploration and Sampling of Soils for Civil Engineering Purposes". Report, Research Project, Committee on Sampling and Testing, Soil Mech. and Found. Div., ASCE, Waterways Experiment Station, Vicksburg.

Jaky,J. 1944. "The Coefficient of Earth Pressure At Rest". J. for Soc. of Hungarian Architects and Engineers, Budapest, Hungary. Oct. 1944, 355-358.

Kenney,T.C. 1966. "Shearing Resistance of Natural Quick Clays". Ph.D. Thesis, University of London, London, England.

Kirkpatrick,W.M. and Rennie,I.A. 1972. "Directional Properties of Consolidated Kaolin". Geotechnique 22, No.1, 166-169.

Kirkpatrick,W.M. 1982. "Stress-Relief Effects on the Undrained Behaviour of Clays". Internal Report CESM 82/01, Department of Civil Engineering, Strathclyde University, Glasgow, Scotland.

Kirkpatrick,W.M. and Khan,A.J. 1984. "The Reaction of Clays to Sampling Stress Relief". Geotechnique 34, No.1, 29-42.

Ladd,C.C. and Lambe,T.W. 1963. "The Strength of 'Undisturbed' Clay Determined from Undrained Tests". ASTM-NRC Symposium on Laboratory Shear Testing of Soils, Ottawa, Canada. ASTM,STP 361, 342-371.

Larsson,R. 1980. "Undrained Shear Strength in Stability Calculation of Embankments and Foundations on Soft Clays". Can. Geotevh. J., Vol.17, 591-602.

Leonards,G.A. and Altschaeffl,A.G. 1964. "Compressibility of Clay". J. of the Soil Mech. and Found. Div., ASCE, Vol.90, No.SM5, 133-156.

Lew,K.V. 1981. "Yielding Criteria and Limit State in a Winnipeg Clay". M.Sc. Thesis, University of Manitoba, Winnipeg, Manitoba.

Lewin,P.I. and Burland,J.B. 1970. "Stress-Probe Experiments on Saturated Normally Consolidated Clay". Geotechnique 20, No.1, 38-56.

Li,E.C.C. 1983. "A Geotechnical Study of Remoulded Winnipeg Clay". M.Sc. Thesis, University of Manitoba, Winnipeg, Manitoba.

Lo,K.Y., and Morin,J.P. 1972. "Strength Anisotropy and Time Effects of Two Sensitive Clays". Canadian Geotechnical Journal, Vol.9, No.3, 261-277.

Lowe,J. 1967. "Stability Analysis of Embankments". J. of the Soil Mech. and Found. Div., ASCE, Vol.93, no.4,

Noonan,M.L. 1980. "Limit-State Studies in Winnipeg Clays". M.Sc. Thesis, University of Manitoba, Winnipeg, Manitoba.

Parry,R.H.G. and Nadarajah,V. 1973. "Observations of Laboratory Prepared, Lightly Overconsolidated Specimens of Kaolin". Geotechnique 24, No.3, 345-358.

Perloff,W.H. and Osterberg,J.O. 1963. "The Effect of Strain Rate on The Undrained Strength of Cohesive Soils". Proc. 2nd Panamerican Conf. Soil Mech. and Found. Eng., Brazil, 1963.

Procter, D.C. 1976. "Requirements of Soil Sampling for Laboratory Testing". "Offshore Soil Mechanics", Cambridge University Engineering Department, 132-153.

Quigley,R.M. and Thompson,C.D. 1966. "The Failure of Anisotropically Consolidated Sensitive Marine Clay". Can. Geotech. J., Vol.3, No.2, 61-73.

Raymond,G.P., Townsend,D.L. and Lojkocek,M.J. 1971. "The Effect of Sampling on the Undrained Soil Properties of Leda Soil". Can. Geotech. J., Vol.8, No.4, 546-557.

Richardson,A.M. and Whitman,R.V. 1963. "Effect of Strain-Rate Upon Undrained Shear Resistance of A Saturated Remoulded Fat Clay". Geotechnique 13, No.3, 310-324.

Rutledge,P.C. 1944. "Relation of Undisturbed Sampling to Laboratory Testing". Transactions, ASCE, Vol.109, 1162-1163.

Sangrey,D.A. 1972. "Naturally Cemented Sensitive Soils". Geotechnique, Vol.22, No.1, 139-152.

Schmertmann,J.H. 1956. Discussion on "Effect of Sample Disturbance on the Strength of a Clay". Transaction ASCE Vol.121, 940-950.

Semple,R.M. and Johnston,J.W. 1979. "Performance of 'Stingray' in Soil Sampling and In Situ Testing". Proc. Offshore Site Investigation, Society for Underwater Technology, London.

Semple,R.M., St. John,H.D. and Toolan,F.E. 1982. "Statement of Research Needs in Offshore Foundation Design". Geotechnics Committee, Society for Underwater Technology, London, England.

Skempton,A.W. 1954. "The Pore Pressure Coefficients A and B". Geotechnique 4, No.4, 143-147.

Skempton,A.W. and Sowa,V.A. 1963. "The Behaviour of Saturated Clays During Sampling and Testing". Geotechnique 13, No.4, 269-290.

Tavenas,F. and Leroueil,S. 1977. "The Effects of Stresses and Time on Yielding of Clays". Proc. 9th Int. Conf. on Soil Mech. and Found. Eng., Tokyo, Vol.1, 319-326.

Trak,B., La Rochelle,P., Tavenas,F., Leoueil,S. and Roy,M. 1980. "New Approach to the Stability Analysis of Embankments on Sensitive Clays". Can. Geotech. J., Vol.17, No.4, 526-544.

Vyas,Y.K., Angemmer,J., Murff,J.D., Neuberger,C.A., McNeilan,T. and Klejbuk Jr.,L.W. 1983. "Deepwater Geotechnical Site Investigation: Santa Ynez Unit, Offshore California". Proc. 15th Offshore Technology Conf., Houston, Texas, Vol.1, 217-226.

Wroth,C.P., Randolph,M.F., Houlsby,G.T. and Fahey,M. 1979. "A Review of the Engineering Properties of Soils with Particular Reference to Shear Modulus". Internal Report CVED/D-Soils TR75, Cambridge University Engineering Department, England.

Wu,T.H., Hsu,J.R. and Ali,E.M. 1983. "Plastic Deformation of an Embankment on Clay". Can. Geotech. J., Vol.20, No.3, 437-452.

TABLE 1

SUMMARY OF TEST PROGRAM

SAMPLE #	T702	T704	T706	T708	T710	T712	T714	T716	T718	T720	T722
OVERCONSOLIDATION RATIO	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
DWELL PERIOD (hours)	-	0.25	24	168	0.25	24	168	0.25	24	168	-
RECONSOLIDATION TYPE	-	CIU	CIU	CIU	CIU	CIU	CIU	CAU	CAU	CAU	-
RECONSOLIDATION LEVEL ($\times \sigma'_{1c}$)	-	0.6	0.6	0.6	1.0	1.0	1.0	1.0	1.0	1.0	-

- not applicable to control samples

TABLE 2

INDEX PROPERTIES OF THE CLAY TESTED (ILLITE) AND GRUNDITE*

SOIL TYPE	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	CLAY FRACTION (<0.002mm) (%)	SPECIFIC GRAVITY
ILLITE	57.2	25.7	61	2.73
GRUNDITE	54.4	26.1	53	2.78

* After Wu et al(1983)

TABLE 3

SUMMARY OF SLURRY CONSOLIDATION

SAMPLE #	T702	T704	T706	T708	T710	T712	T714	T716	T718	T720	T722
MOISTURE CONTENT OF SLURRY (%)	114.7	115.3	115.2	110.5	113.9	113.7	114.0	111.0	115.0	113.8	114.0
PERIOD UNDER 70kPa (DAYS)	8	13	-	6	7	9	10	9	8	11	13
MOISTURE CONTENT AT 70kPa AFTER 24 HOURS (%)	63.7	57.6	-	50.6	56.2	52.3	54.2	64.7	61.4	65.3	57.3
MEASURED MOISTURE CONTENT AFTER CONSOLIDATION (%)	52.1	47.5	47.3	45.8	46.2	47.4	46.5	50.0	49.2	50.7	47.1
CALCULATED MOISTURE CONTENT AFTER CONSOLIDATION (%)	50.8	48.4	52.1	46.6	49.1	50.3	45.7	47.4	49.4	49.8	47.5
λ_1	0.583	0.652	-	0.726	0.634	0.574	0.665	0.532	0.639	0.580	0.621

- not available

TABLE 4

TRIAXIAL CONSOLIDATION RESULTS

SAMPLE #	T702	T704	T706	T708	T710	T712	T714	T716	T718	T720	T722
σ'_{cyl} (kPa)	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0
σ'_y (kPa) *	71.4	71.6	71.0	72.6	73.9	69.9	73.2	70.6	71.7	75.8	72.6
σ'_{vc} (kPa)	160.2	160.0	160.1	160.2	160.1	159.9	160.0	159.9	160.1	160.0	160.0
σ'_{1c} (kPa)	79.89	79.59	79.71	79.66	79.72	79.73	79.72	79.71	79.63	79.72	79.71
$\sigma'_{3c}/\sigma'_{1c}$	0.57	0.53	0.55	0.54	0.53	0.46	0.53	0.53	0.53	0.53	0.53
ϵ_{1c} (%)	9.2	8.0	7.3	6.2	7.7	9.7	7.2	9.5	8.6	8.1	7.4
ϵ_{3c} (%)	1.6	0.6	0.7	1.1	1.0	0.2	0.6	0.2	0.6	0.6	0.2
v_c (%)	12.3	9.2	8.7	8.5	9.6	10.1	8.4	10.0	9.8	9.4	7.8
$\epsilon_{1c}/\epsilon_{3c}$	5.8	13.3	10.4	5.6	7.7	48.5	12.0	47.5	14.3	13.5	37.0
λ_1 @	0.583	0.652	-	0.726	0.634	-	0.665	0.532	0.639	0.580	0.621
κ_1	0.168	-	0.080	0.083	0.107	-	0.072	0.117	0.099	0.098	-
λ_2	0.246	-	0.202	0.206	0.204	0.238	0.220	0.227	0.238	0.245	0.234
κ_2	0.049	0.050	0.046	0.045	0.043	0.043	0.045	0.055	0.050	0.048	0.050
K_{eq} (kPa)	539	1019	1125	1066	830	937	1335	806	936	971	1682
K_{eq}/σ'_{cyl}	7.7	14.6	16.1	15.2	11.9	13.4	19.1	11.5	13.4	13.9	24.0
G_{eq} (kPa)	392	885	1290	1237	766	738	1209	614	924	1113	1039
G_{eq}/σ'_{cyl}	5.6	12.6	18.4	17.7	10.9	10.5	17.3	8.8	13.2	15.9	14.8

* from Table 5
@ from Table 3
\- not available

TABLE 5

YIELD STRESS FROM DIFFERENT CRITERIA (VERTICAL STRESS IN kPa)

SAMPLE #	T702	T704	T706	T708	T710	T712	T714	T716	T718	T720	T722
σ_3'/σ_1' AT YIELD	0.569	0.529	0.553	0.545	0.538	0.474	0.530	0.530	0.529	0.529	0.529
log(P)-V	68.2	-	72.0	77.1	75.0	-	73.7	70.7	74.3	76.1	-
P-V	-	69.7	-	-	-	-	71.7	-	-	-	71.8
$q-\varepsilon$	-	72.0	-	76.3	72.1	-	75.7	-	70.5	76.5	73.7
$\sigma_1 - \varepsilon_1$	-	72.1	-	71.2	74.3	-	73.7	-	68.2	73.7	73.2
$P-\varepsilon_1$	-	70.4	-	70.0	73.6	-	71.7	-	74.7	74.7	72.5
W-LSSV	74.6	73.6	69.8	68.8	75.3	69.3	72.8	70.3	70.6	77.8	71.9
AVERAGE σ_1	71.4	71.6	70.9	72.7	74.1	69.3	73.2	70.6	71.7	75.8	72.6
% DIFF. WITH 70kPa	-2.0	-2.2	-1.3	-3.8	-5.8	+1.0	-4.5	-0.9	-2.4	-8.2	-3.7

- not available

TABLE 6

SUMMARY OF UNDRAINED SHEAR TEST RESULTS

SAMPLE #	T702	T704	T706	T708	T710	T712	T714	T716	T718	T720	T722
TEST TYPE	CAU	CIU	CIU	CIU	CIU	CIU	CIU	CAU	CAU	CAU	CAU
RECON. σ'_3 (kPa)	-	48	48	48	80	80	80	42.4	42.4	42.4	-
RECON. σ'_1 (kPa)	-	48	48	48	80	80	80	80	80	80	-
DWELL TIME (hr)	-	0.25	24	168	0.25	24	168	0.25	24	168	-
σ'_{vc} (kPa)	160.2	160.0	160.1	160.2	160.1	159.9	160.0	159.9	160.1	160.0	160.0
σ'_{1c} (kPa)	79.9	79.6	79.7	79.7	79.7	79.7	79.7	79.7	79.6	79.7	79.7
$\sigma'_{3c}/\sigma'_{1c}$	0.57	0.53	0.55	0.54	0.53	0.46	0.53	0.53	0.53	0.53	0.53
OCR	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
$\Delta\epsilon_{1rc}$(%) *	-	-2.2	0.07	-0.06	0.15	0.12	0.41	0.05	0.04	0.10	-
$\Delta\epsilon_{3rc}$ (%) *	-	0.03	-0.14	-0.12	0.43	0.42	0.60	-0.01	-0.06	-0.03	-
Δv_{rc} (%) *	-	-0.16	-0.21	-0.31	1.02	0.96	1.32	0.04	-0.07	0.04	-
$q_y/2$ (kPa)	41.4	34.5	35.8	33.3	45.4	52.2	41.3	37.0	37.7	38.3	37.1
$q_y/2\sigma'_{vc}$	0.258	0.216	0.224	0.208	0.284	0.326	0.258	0.231	0.235	0.239	0.232
ϵ_1 at q_y (%)	0.75	1.44	1.39	1.32	1.49	1.68	1.71	1.18	1.01	0.99	0.65
$q_{max}/2$ (kPa)	43.7	36.2	37.8	36.4	50.5	55.2	43.7	38.4	39.4	39.7	39.0
$q_{max}/2\sigma'_{vc}$	0.273	0.226	0.236	0.227	0.315	0.345	0.273	0.240	0.246	0.248	0.244
ϵ_1 at q_{max} (%)	1.66	2.56	2.67	5.03	6.85	3.06	2.93	1.98	2.94	1.95	1.98
p' at q_{max} (kPa)	76.2	59.1	59.5	58.5	86.7	108.0	74.2	63.3	65.2	61.9	63.1
A_f at q_y	0.19	0.25	0.24	0.27	0.31	0.31	0.42	0.17	0.15	0.23	0.20
B (%)	98	96	96	98#	99	98	97	97	97	98	98
m	0.82	1.36	1.11	0.90	1.56	1.10	1.50	1.08	1.03	1.20	1.25
$\rho_{0.1}$ (%)	10.6	6.5	6.8	4.7	9.3	+	8.4	3.8	4.5	5.1	5.1
ϵ_{ps} (%)	3.11	3.14	3.39	3.21	2.85	+	2.93	3.42	3.77	3.29	2.90
ϵ_{pe} (%)	3.29	3.26	3.51	3.32	3.04	+	3.08	3.52	3.92	3.39	3.03
E_{50} (MPa) @	13.8	12.5	12.3	12.7	11.6	12.8	11.1	8.9	8.3	9.2	23.1
$E_{50}/0.5q_y$ @	333	362	343	382	255	245	268	240	221	241	623
E_{50}/σ'_{vc} @	86.0	78.1	76.7	79.4	72.3	80.2	69.1	55.6	52.0	57.7	144.6
G/σ'_{vc} @	28.7	26.0	25.6	26.5	24.1	26.7	23.0	18.5	17.3	19.2	48.2

- not applicable
* positive compression, negative expansion
\# B value based on response at 5 minutes after increase of cell pressure
\+ not available
@ calculated using q_y

TABLE 7

BASIC SOIL PROPERTIES AND MOISTURE CONTENTS(%) AT DIFFERENT STAGES

SAMPLE #	T702	T704	T706	T708	T710	T712	T714	T716	T718	T720	T722
LIQUID LIMIT (%)	-	61.5	-	57.4	-	55.7	58.7	57.4	56.9	54.9	61.0
PLASTIC LIMIT (%)	-	27.1	-	26.5	-	24.8	25.6	25.6	25.6	25.0	25.6
PLASTICITY INDEX (%)	-	34.4	-	30.9	-	30.9	33.1	31.8	31.3	29.9	35.4
BEFORE CYLINDER CONSOLIDATION	114.7	115.3	115.2	110.5	113.9	113.7	114.0	111.0	115.0	113.8	114.0
BEFORE TRIAXIAL CONSOLIDATION (MEASURED)	52.1	47.5	47.3	45.8	46.2	47.4	46.5	50.0	49.2	50.7	47.1
AFTER TRIAXIAL CONSOLIDATION	41.2	39.8	40.0	38.8	38.2	38.8	39.5	41.3	40.8	42.5	40.6
BEFORE SHEARING	41.2	39.9	40.2	39.1	37.4	38.0	38.4	41.3	40.8	42.5	40.6
AFTER SHEARING (MEASURED)	41.0	40.7	41.0	39.9	37.4	36.4	39.4	41.5	41.3	43.7	41.1

- not available

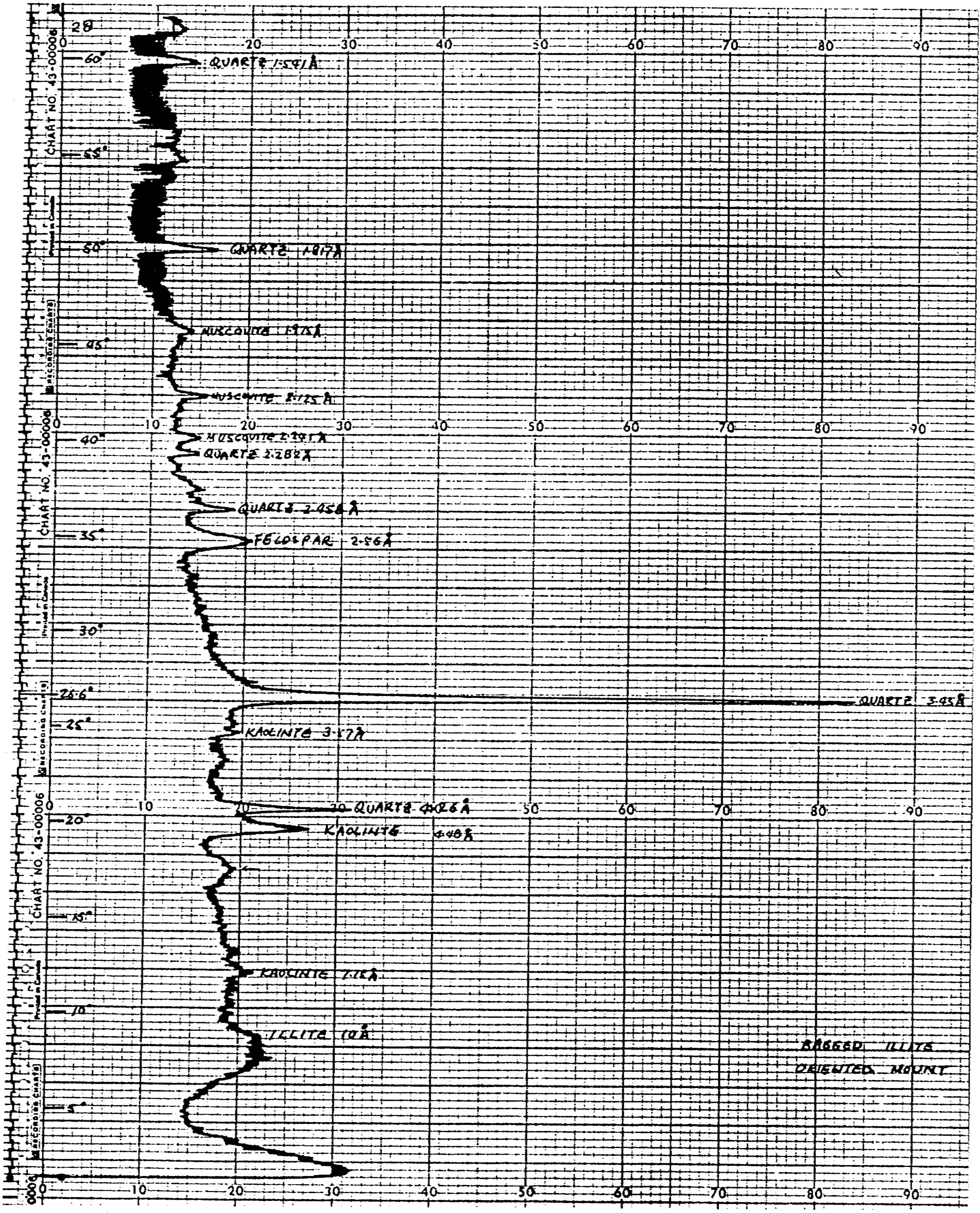


FIGURE 4.1 - X-RAY DIFFRACTOGRAM, ILLITIC CLAY FROM GRUNDY COUNTY, ILLINOIS, ORIENTED MOUNT

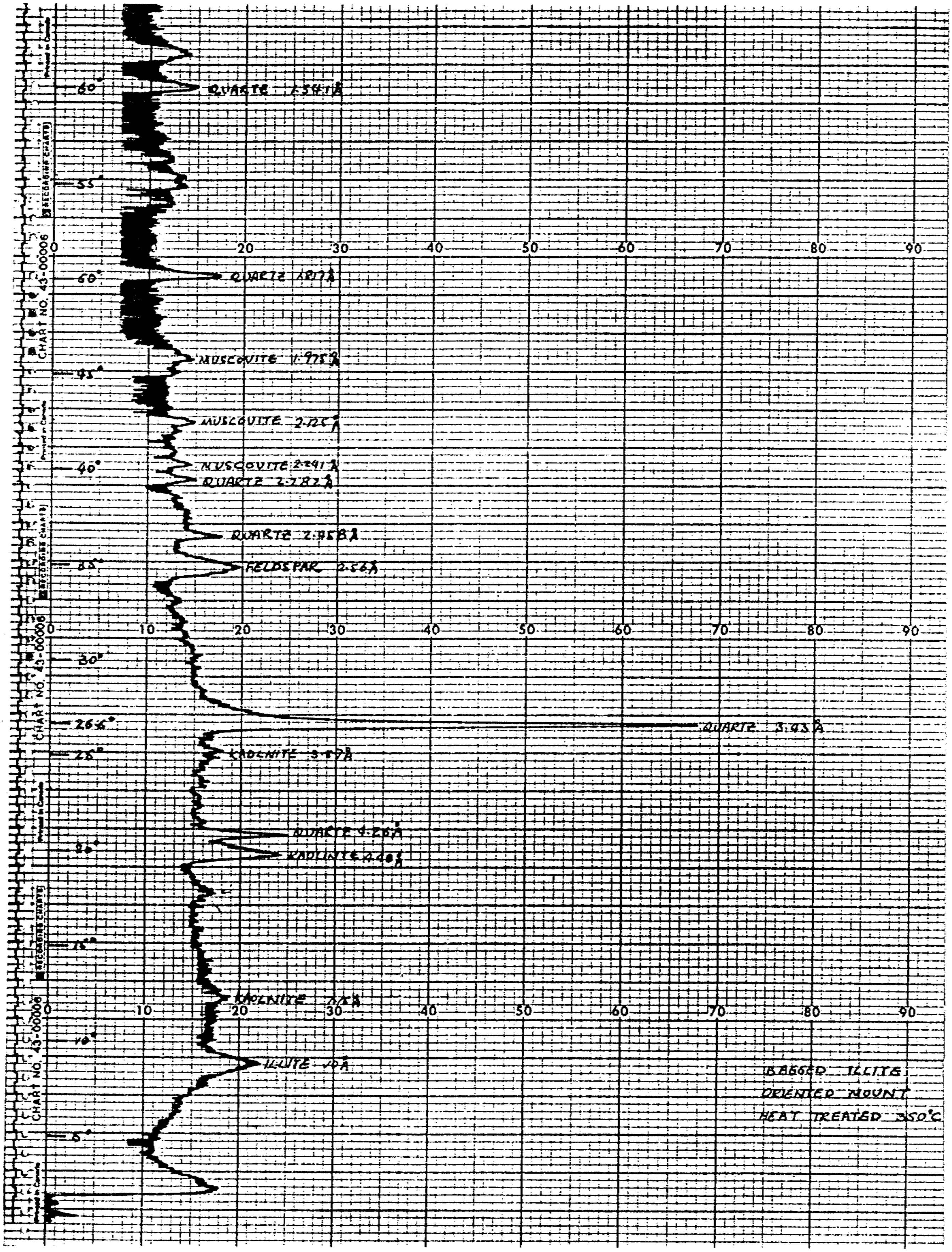


FIGURE 4.2 - X-RAY DIFFRACTOGRAM, ILLITIC CLAY FROM GRUNDY COUNTY, ILLINOIS, ORIENTED MOUNT, HEAT TREATED TO 350°C

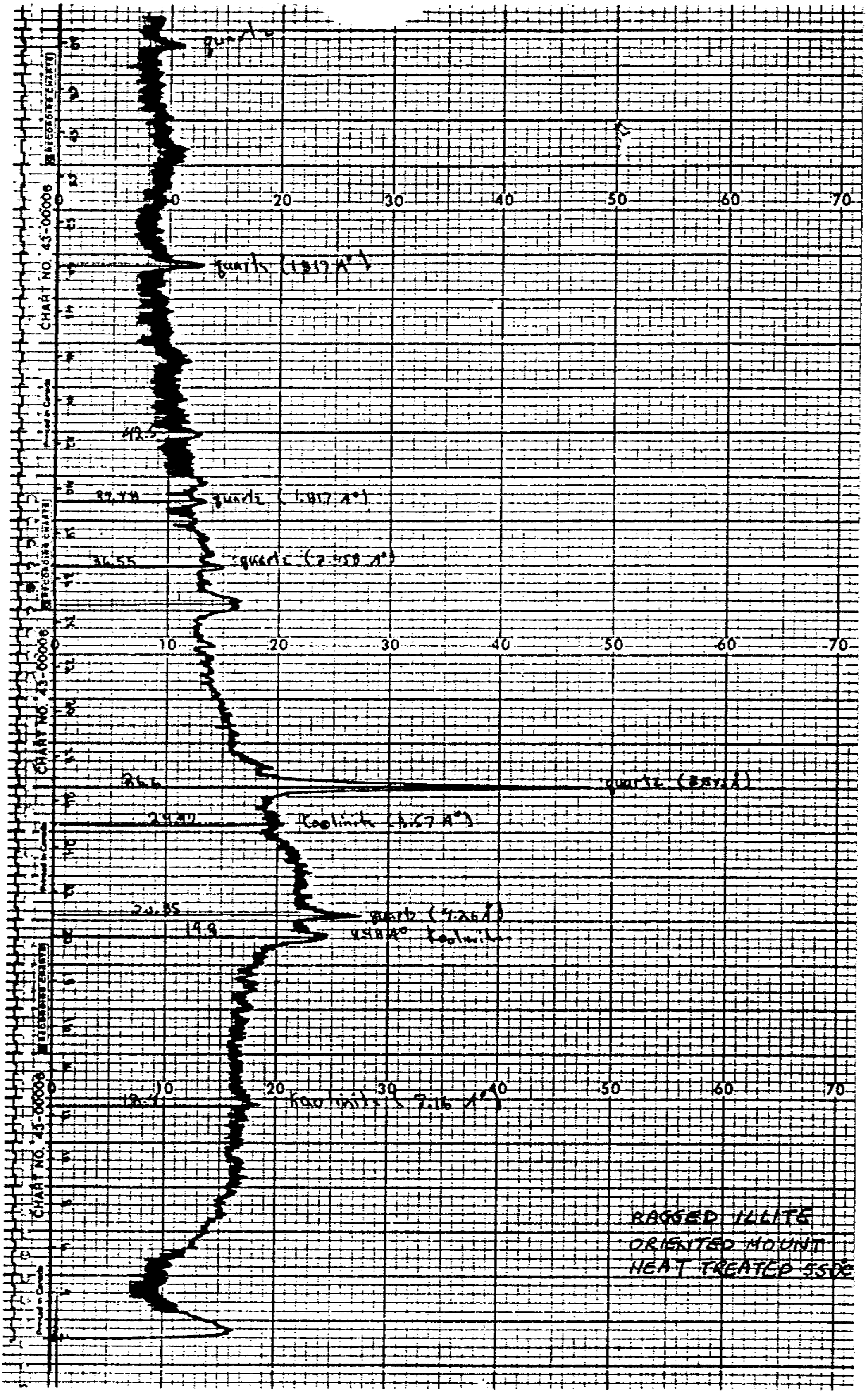


FIGURE 4.3 - X-RAY DIFFRACTOGRAM, ILLITIC CLAY FROM GRUNDY COUNTY, ILLINOIS, ORIENTED MOUNT, HEAT TREATED TO 550°C

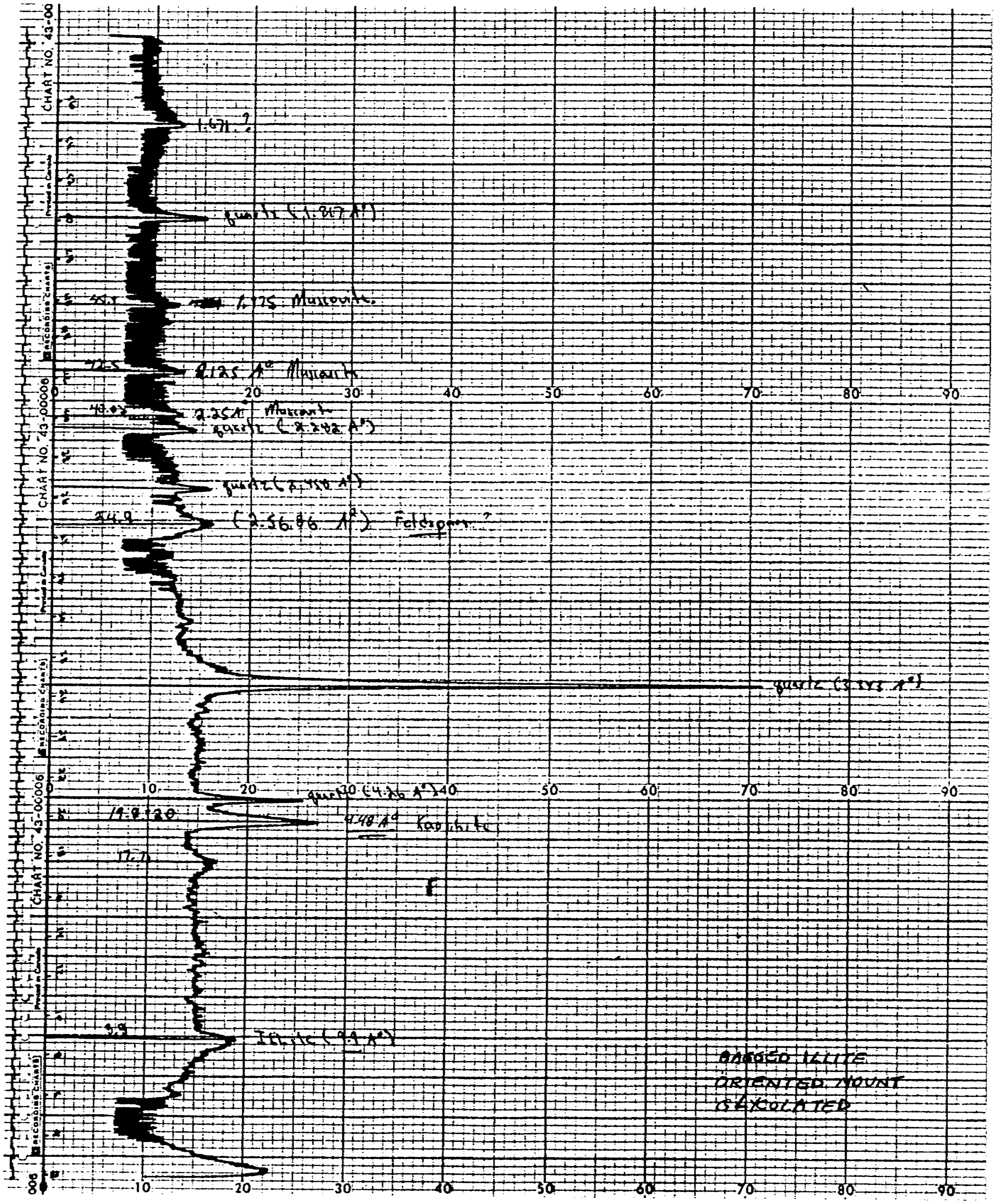


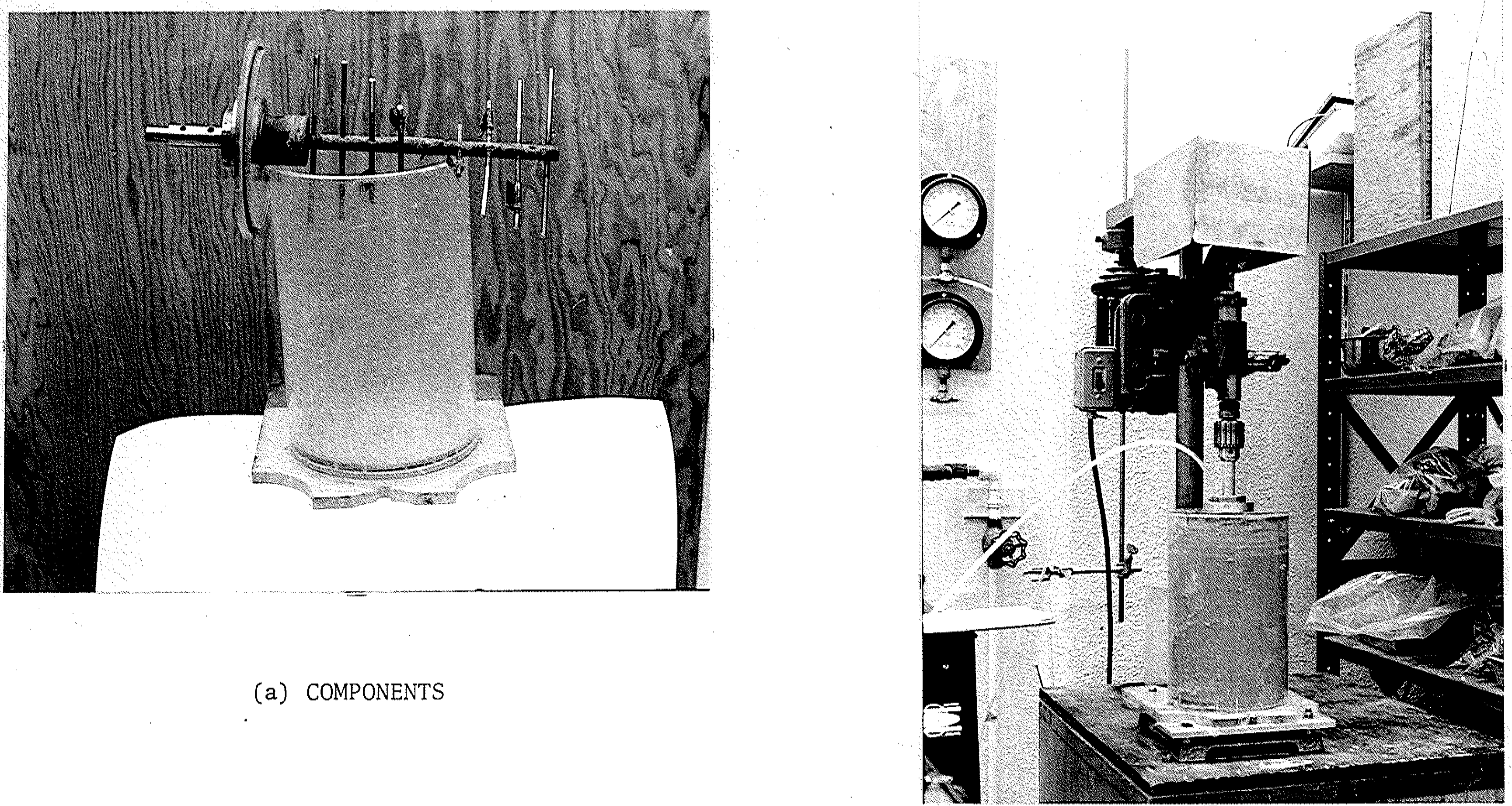
FIGURE 4.4 - X-RAY DIFFRACTOGRAM, ILLITIC CLAY FROM GRUNDY COUNTY, ILLINOIS, ORIENTED MOUNT, GLYCOLATED

NOTICE/AVIS

PAGE(S) 103-106 ~~IS~~/ARE ~~EST~~/SONT black + white photos

PLEASE WRITE TO THE AUTHOR FOR INFORMATION, OR CONSULT THE ARCHIVAL COPY HELD IN THE DEPARTMENT OF ARCHIVES AND SPECIAL COLLECTIONS, ELIZABETH DAFOE LIBRARY, UNIVERSITY OF MANITOBA, WINNIPEG, MANITOBA, CANADA, R3T 2N2.

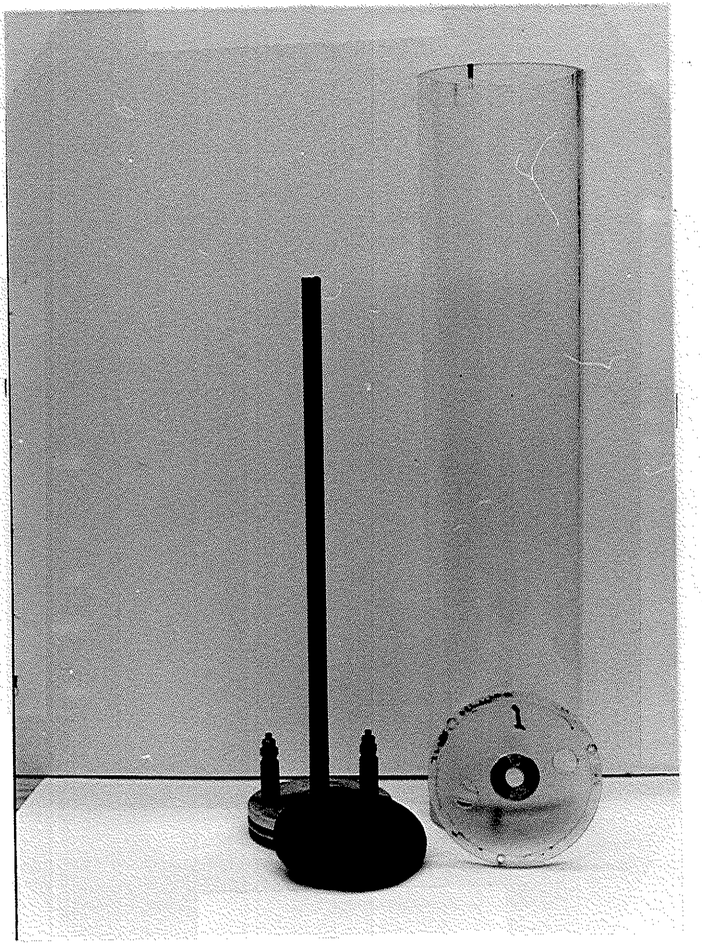
VEUILLEZ ECRIRE A L'AUTEUR POUR LES RENSEIGNEMENTS OU VEUILLEZ CONSULTER L'EXEMPLAIRE DONT POSSEDE LE DEPARTEMENT DES ARCHIVES ET DES COLLECTIONS SPECIALES, BIBLIOTHEQUE ELIZABETH DAFOE, UNIVERSITE DU MANITOBA, WINNIPEG, MANITOBA, CANADA, R3T 2N2.



(a) COMPONENTS

(b) IN OPERATION

FIGURE 4.5a,b - MECHANICAL MIXING UNIT



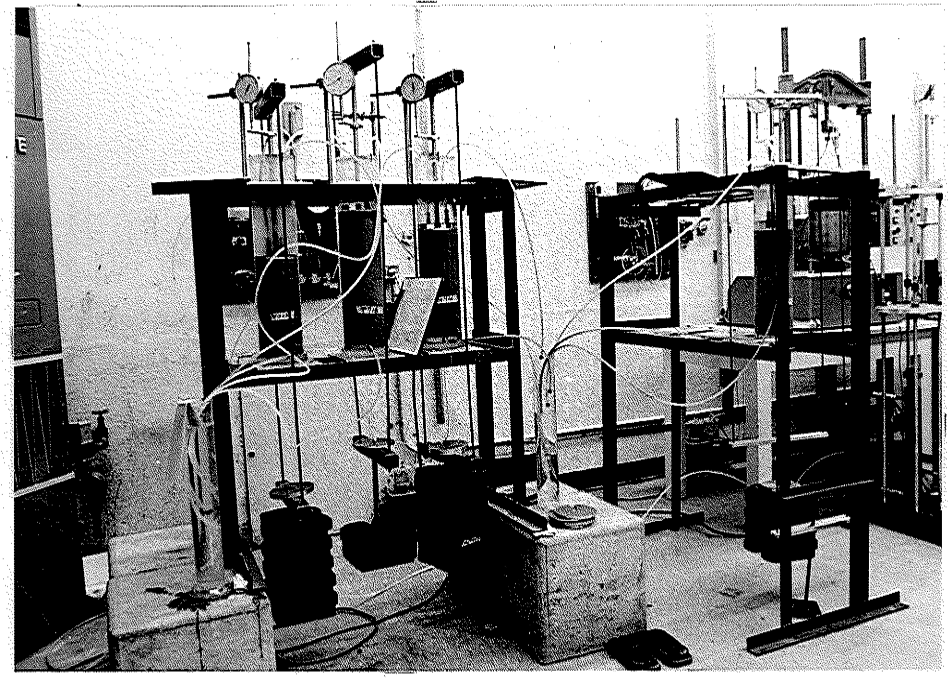
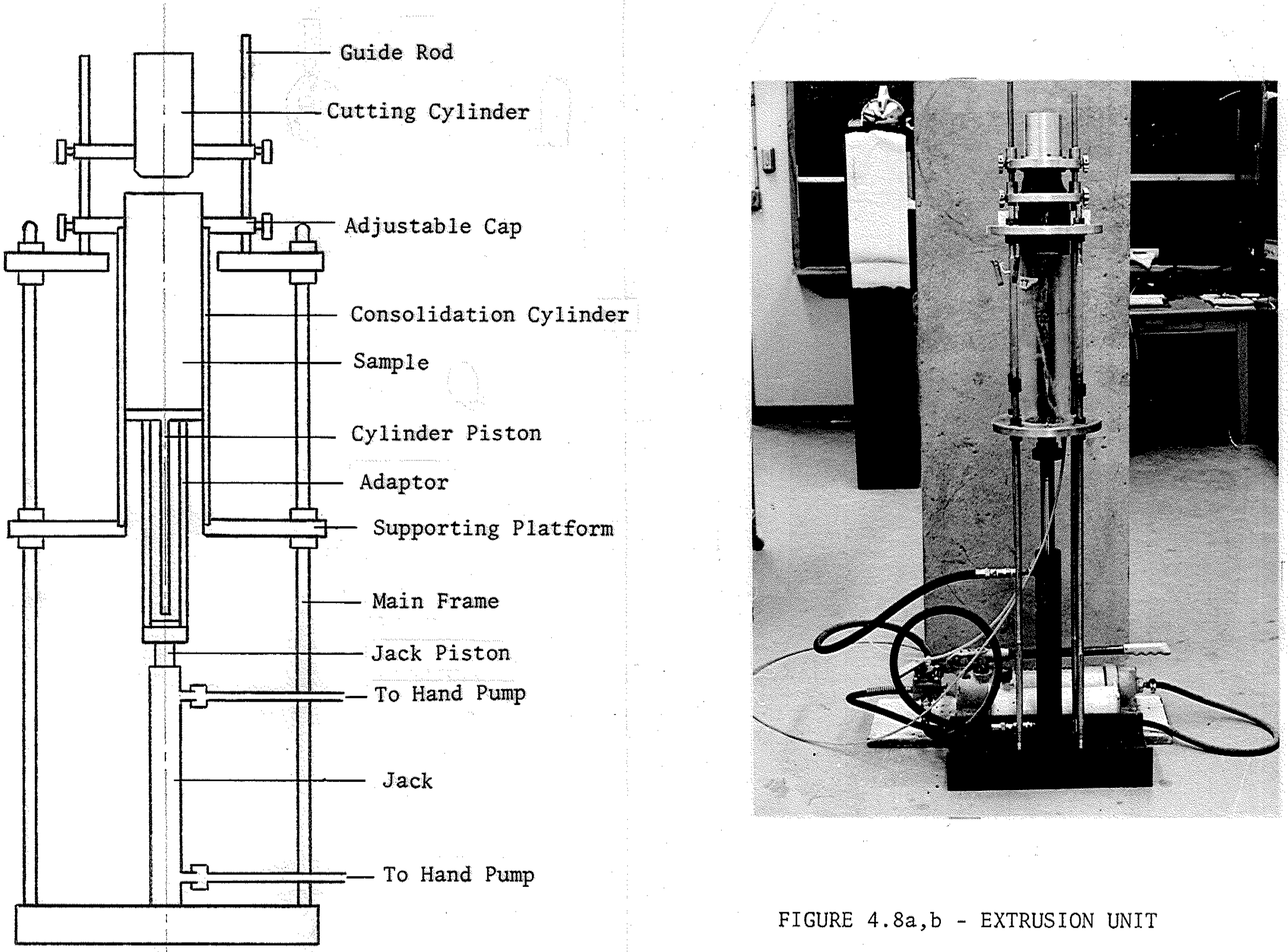


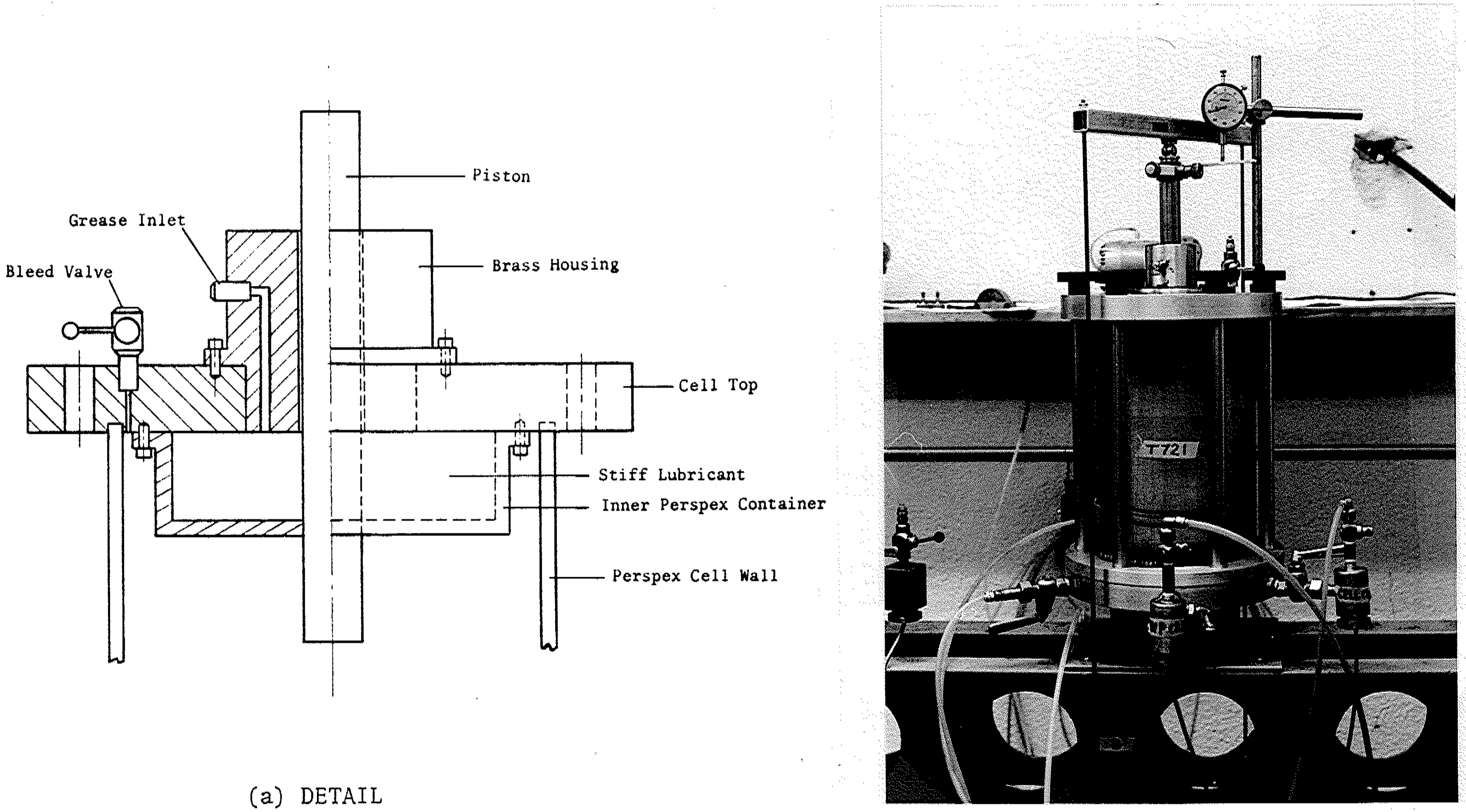
FIGURE 4.7 - SLURRY CONSOLIDATION IN PROGRESS

FIGURE 4.6 - SLURRY CONSOLIDATION APPARATUS



NOT TO SCALE

FIGURE 4.8a,b - EXTRUSION UNIT



(a) DETAIL

(b) IN OPERATION

FIGURE 4.9a,b - PISTON HOUSING MODIFICATION

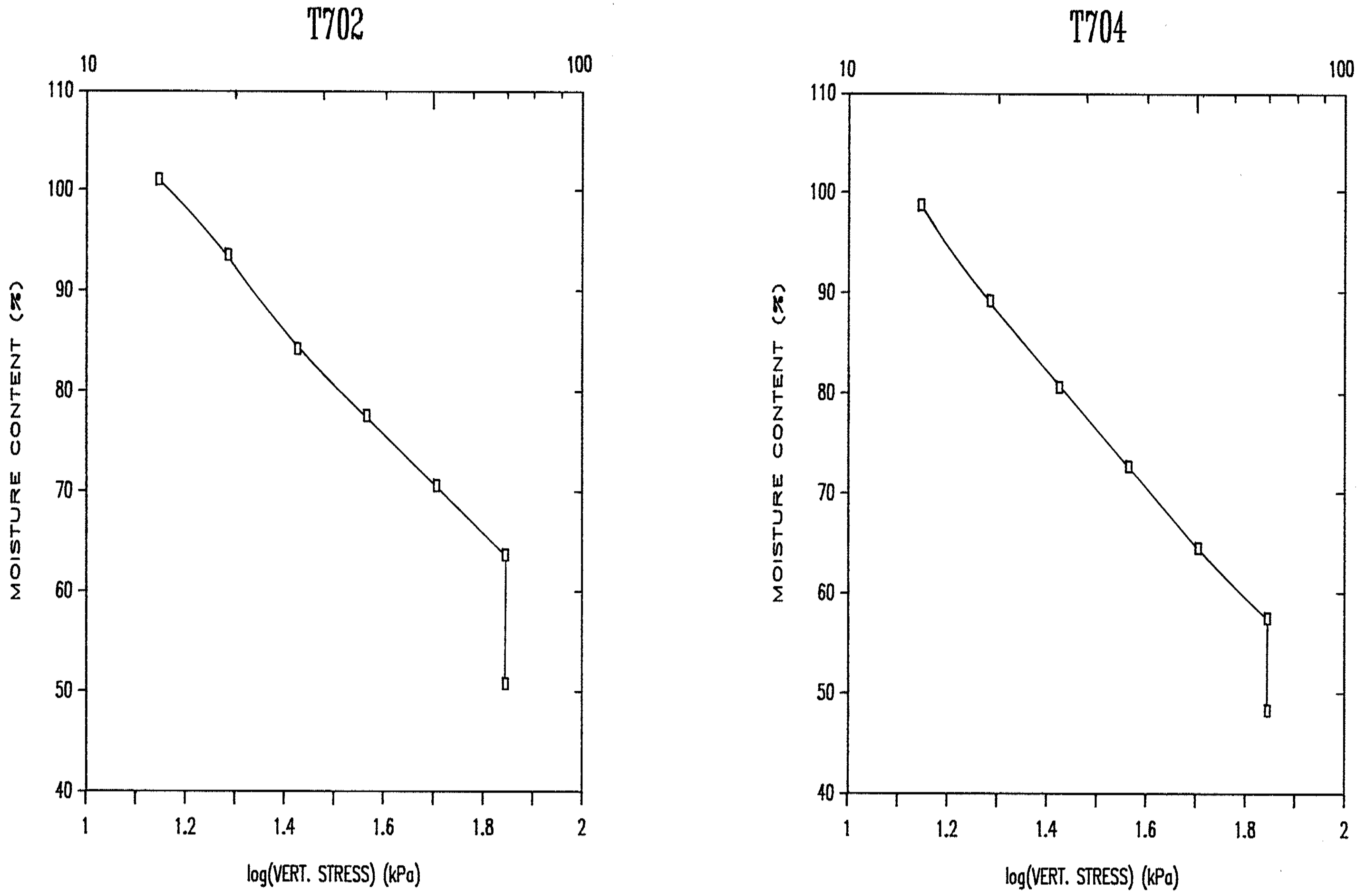


FIGURE 5.1a,b - CYLINDER CONSOLIDATION, $\log(\sigma_v)$ vs w, T702, T704

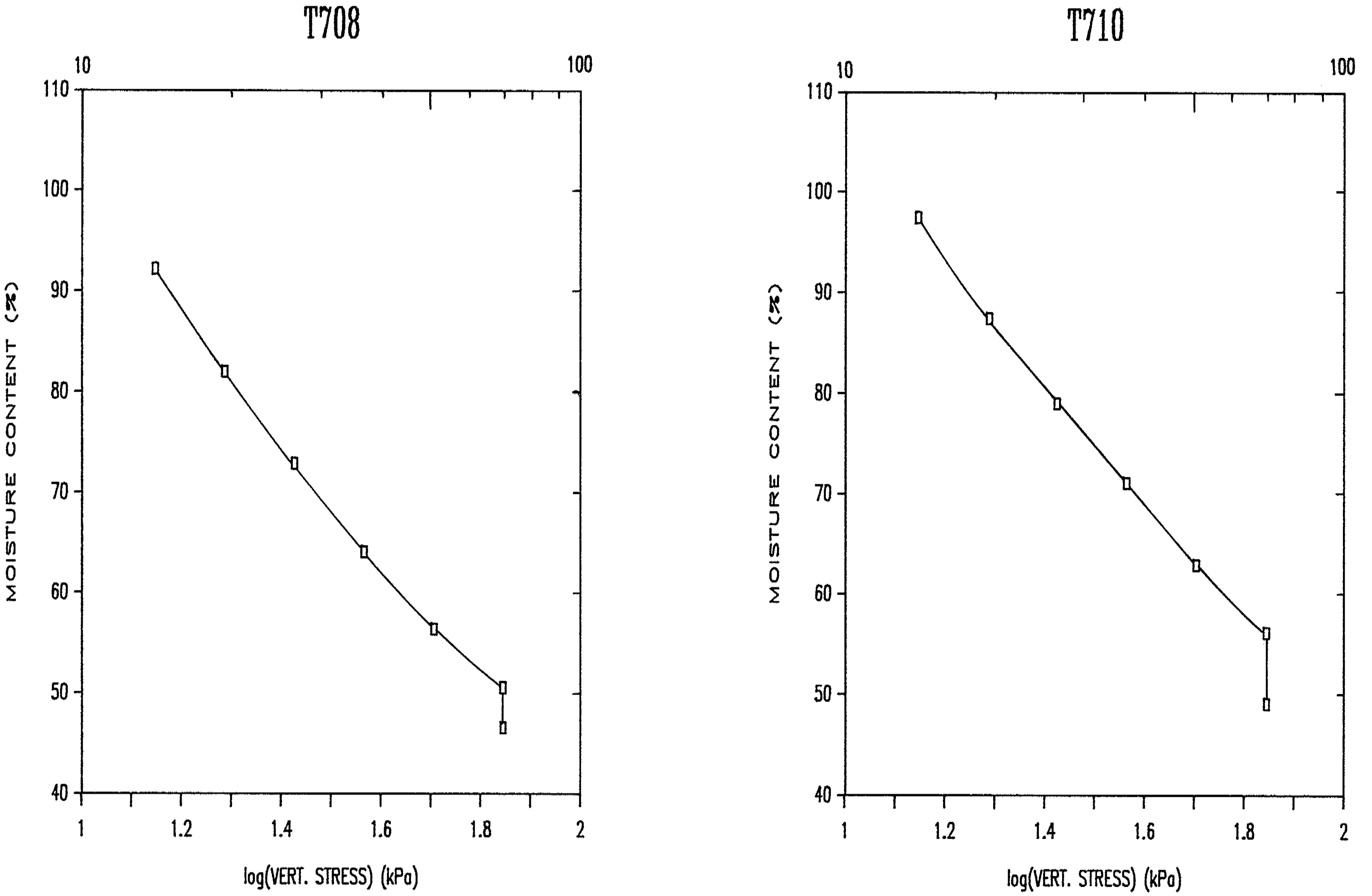


FIGURE 5.2a,b - CYLINDER CONSOLIDATION,
log(σ_v) vs w, T708, T710

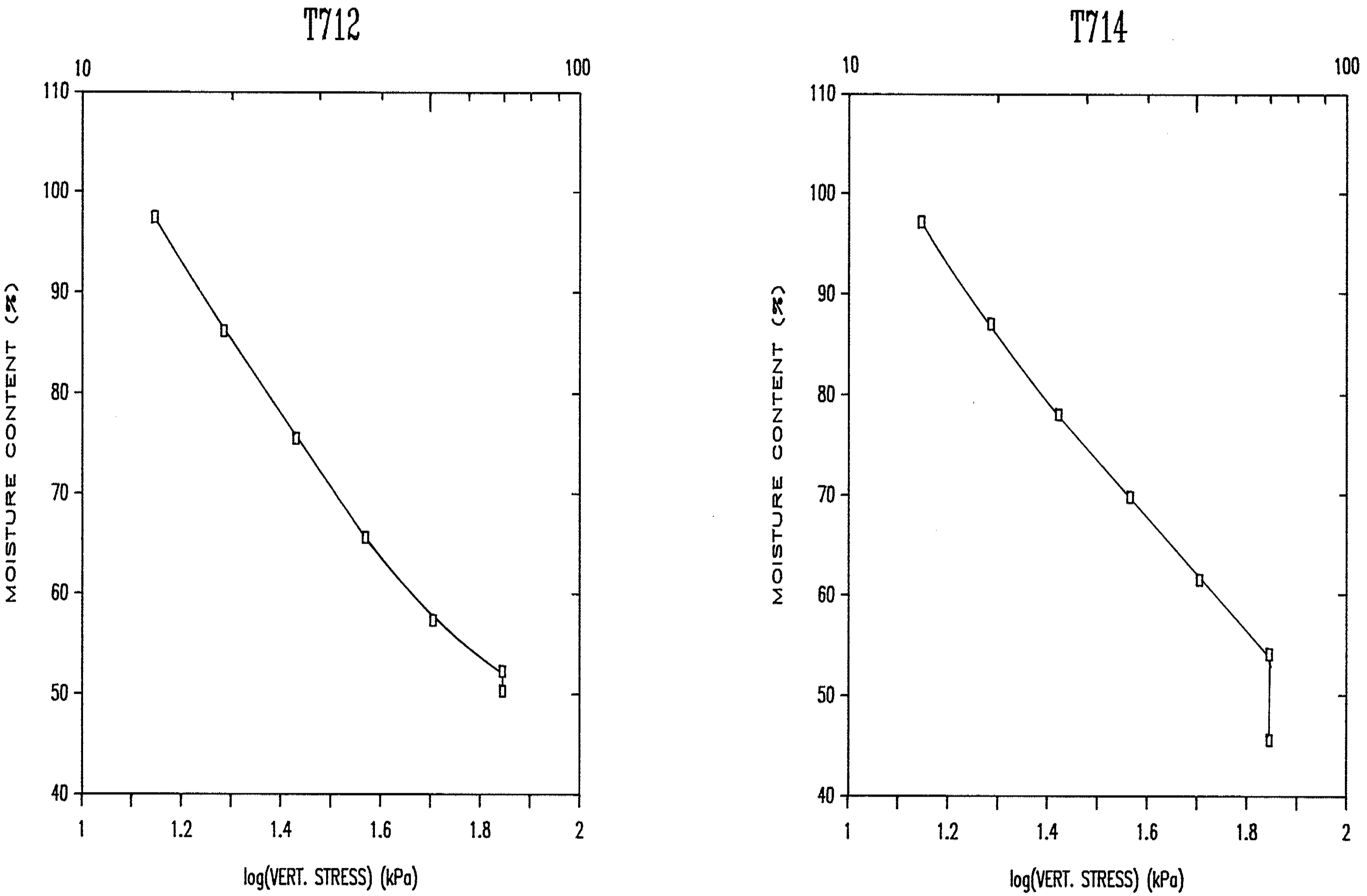


FIGURE 5.3a,b - CYLINDER CONSOLIDATION, log(σ_v) vs w, T712, T714

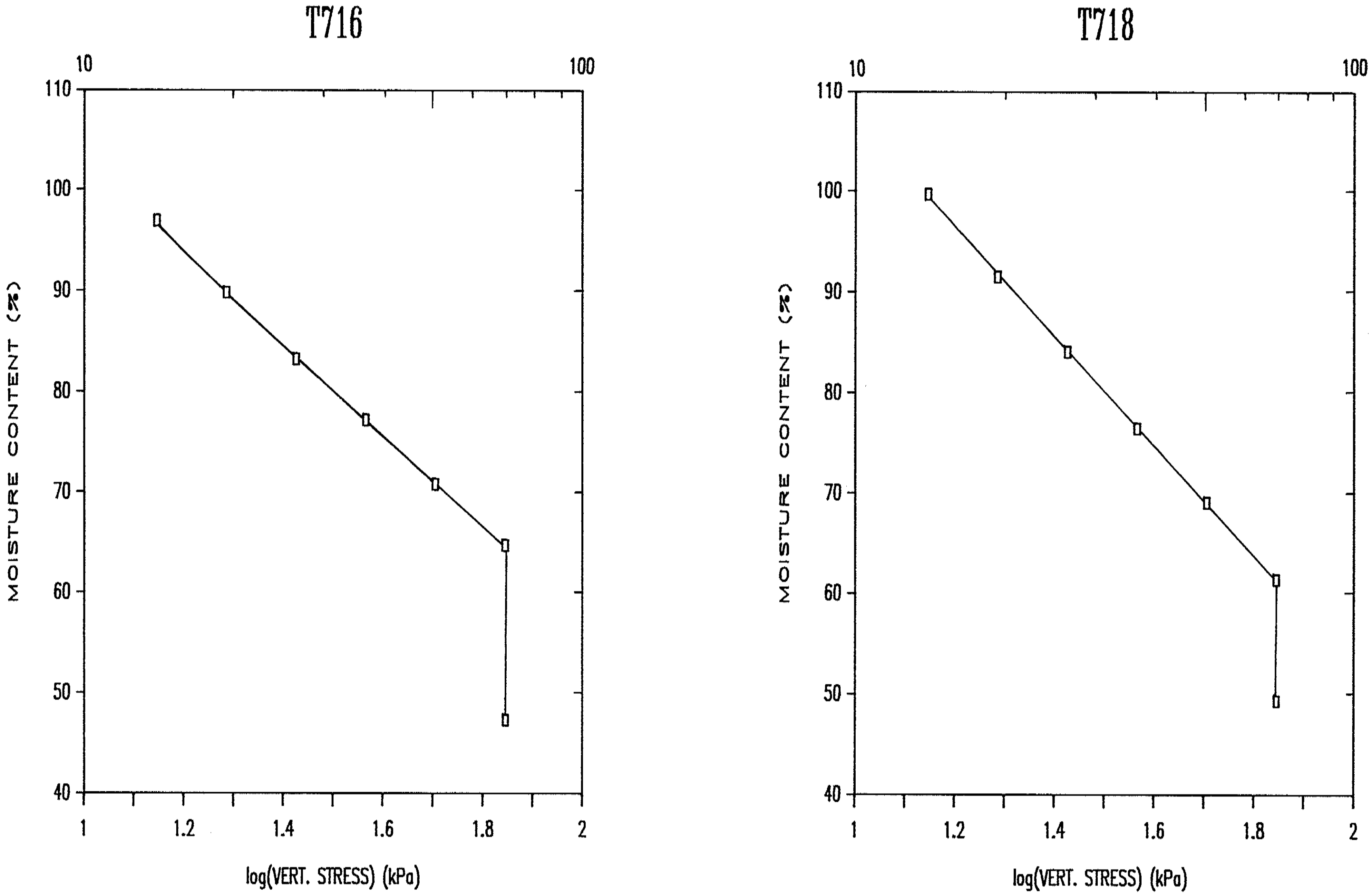


FIGURE 5.4a,b - CYLINDER CONSOLIDATION, $\log(\sigma_v)$ vs w, T716, T718

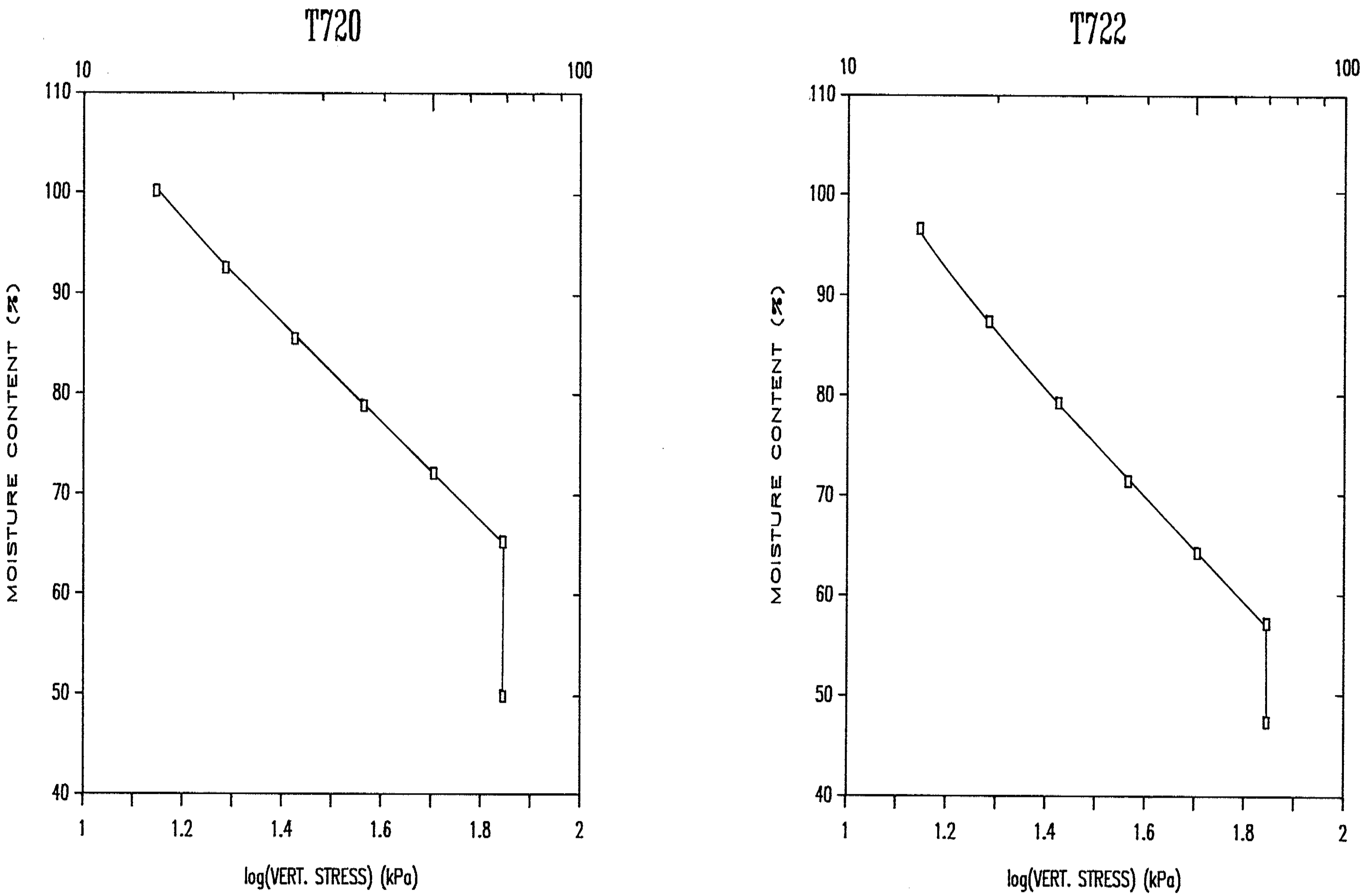


FIGURE 5.5a,b - CYLINDER CONSOLIDATION,
log(σ_v) vs w, T720, T722

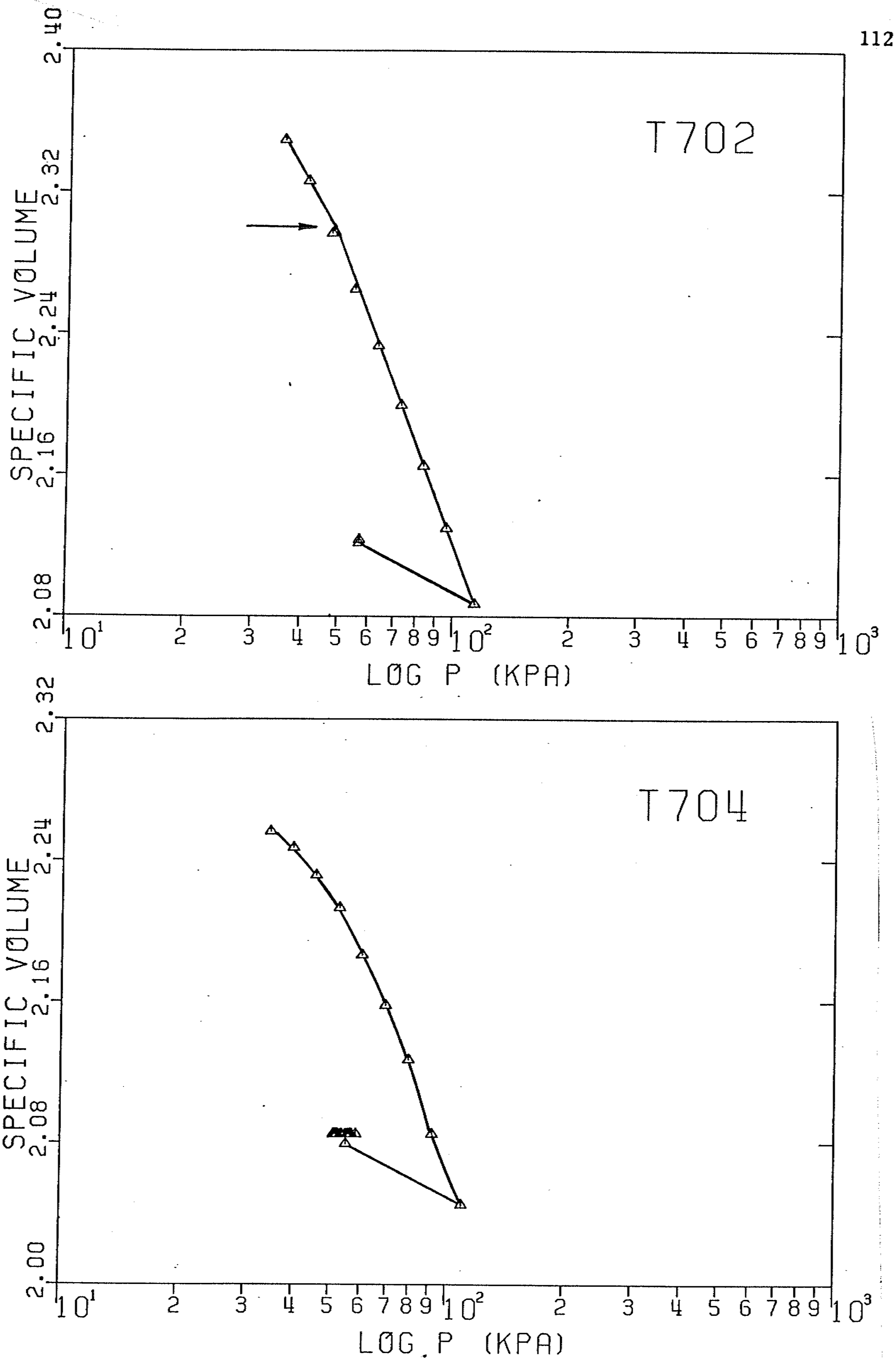
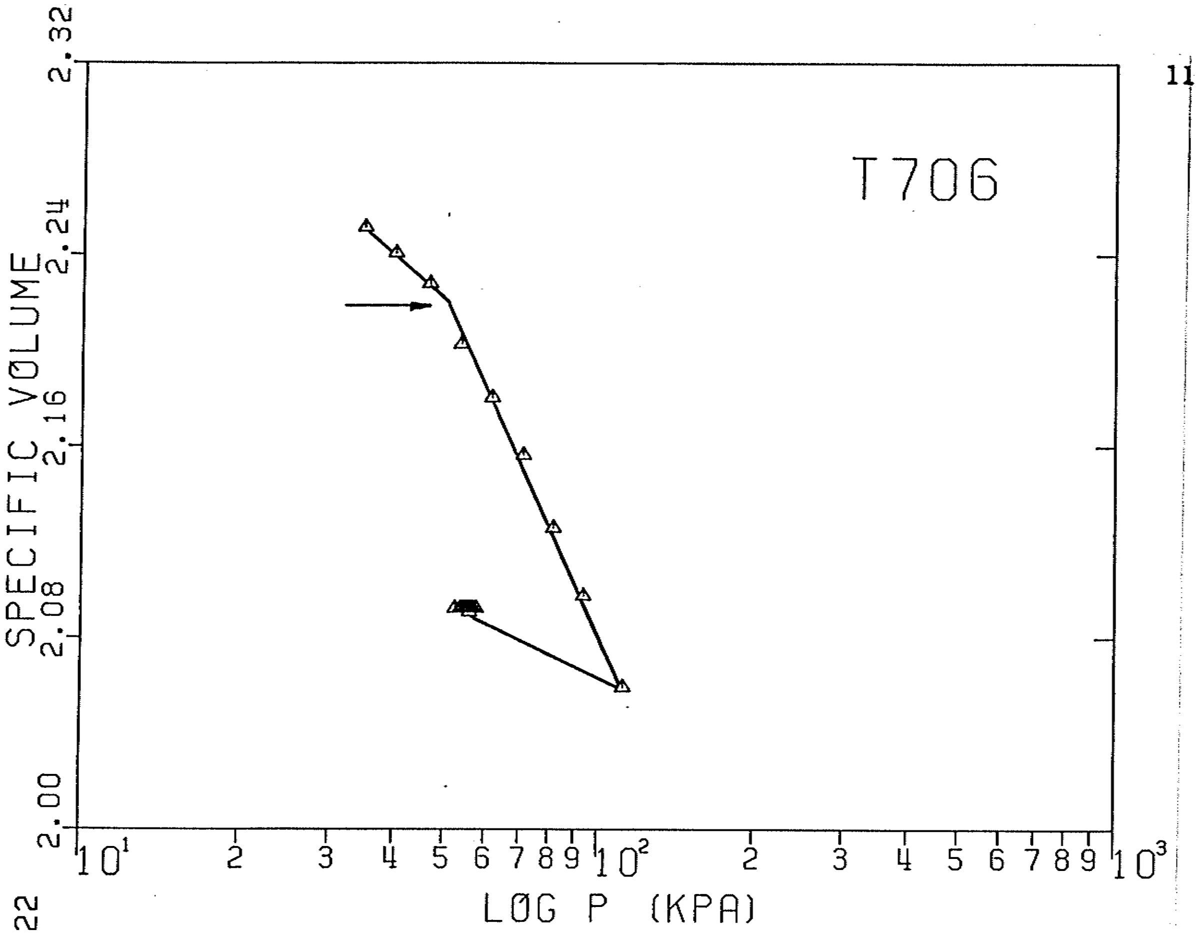


FIGURE 5.6a,b - TRIAXIAL CONSOLIDATION AND YIELD DETERMINATION log(p') vs V, T702, T704



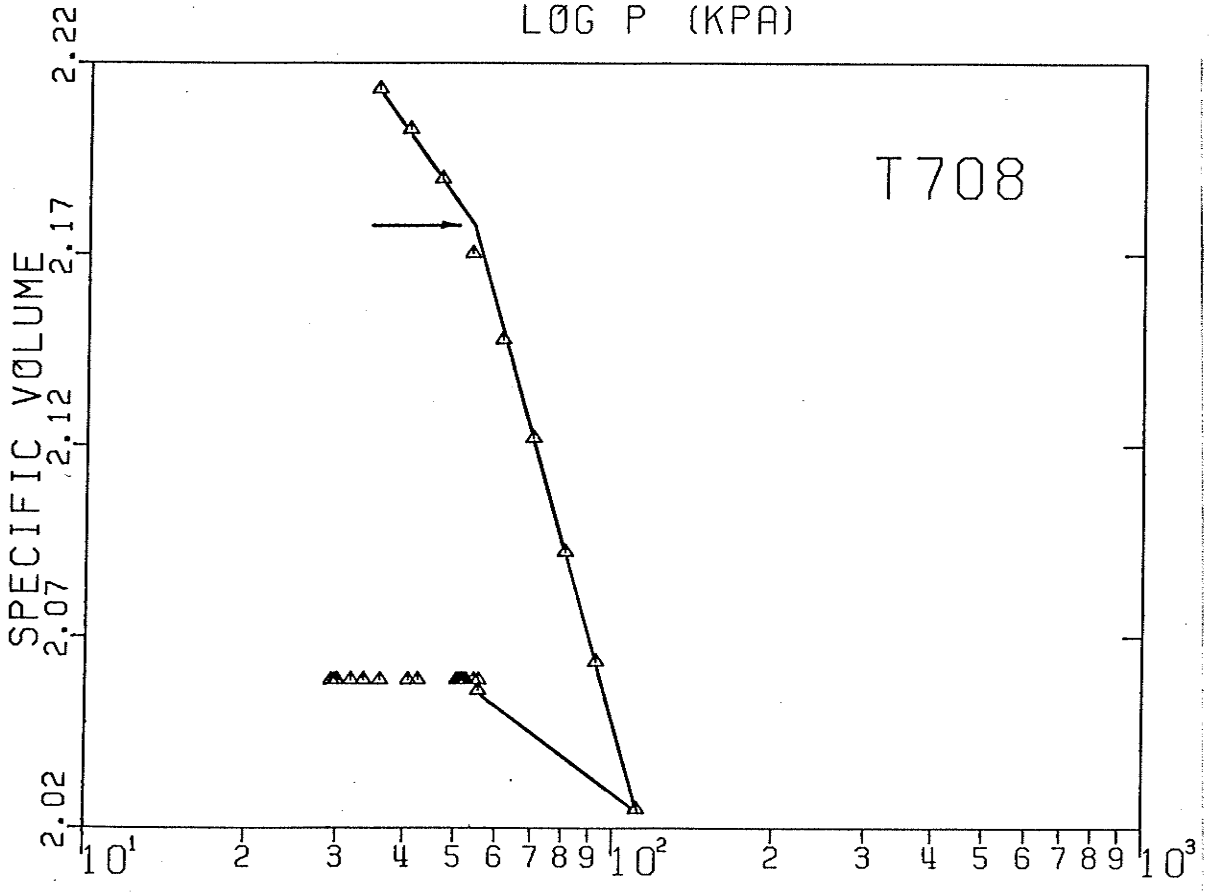


FIGURE 5.7a,b - TRIAXIAL CONSOLIDATION AND YIELD DETERMINATION log(p') vs V, T706, T708

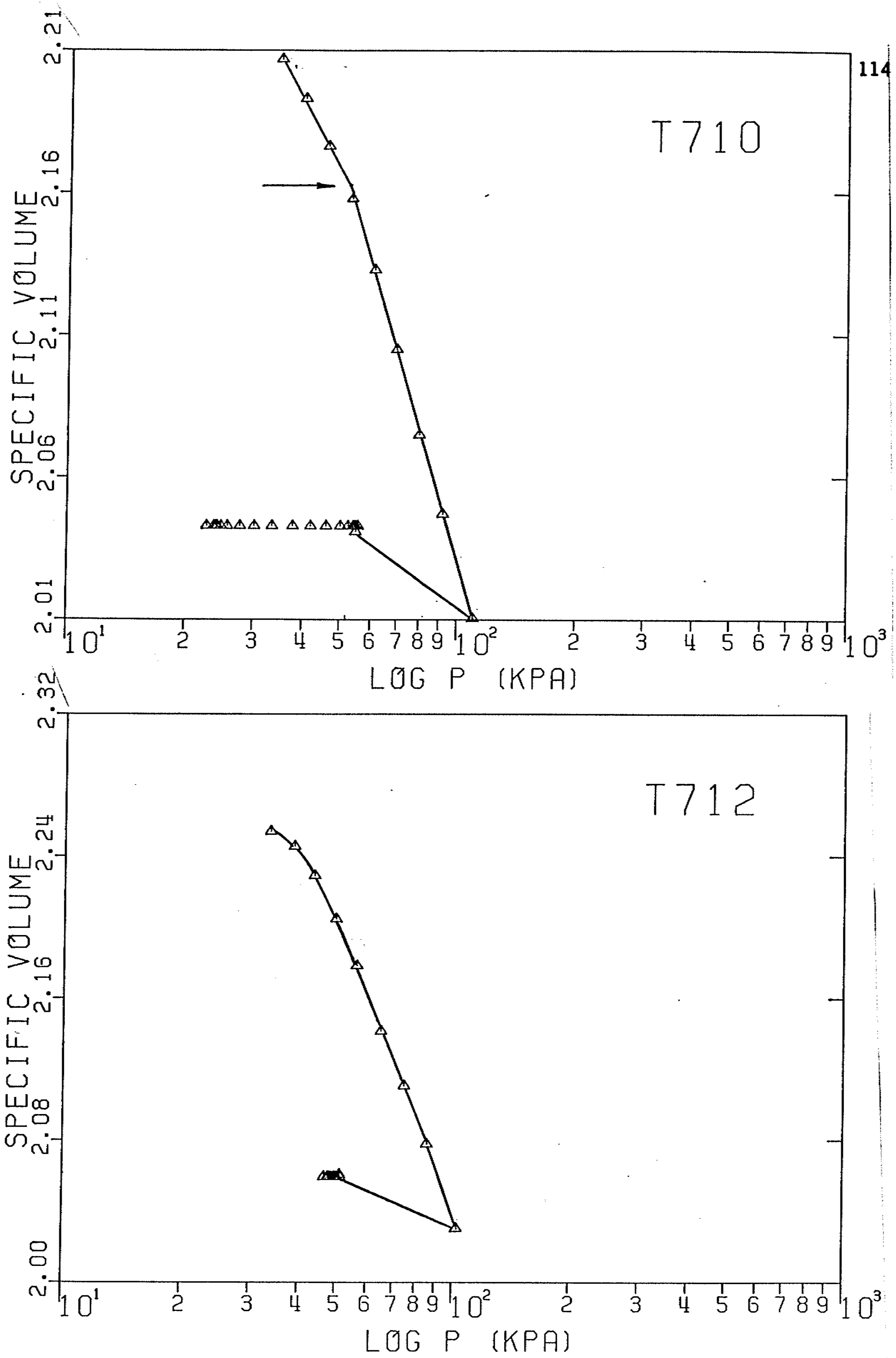
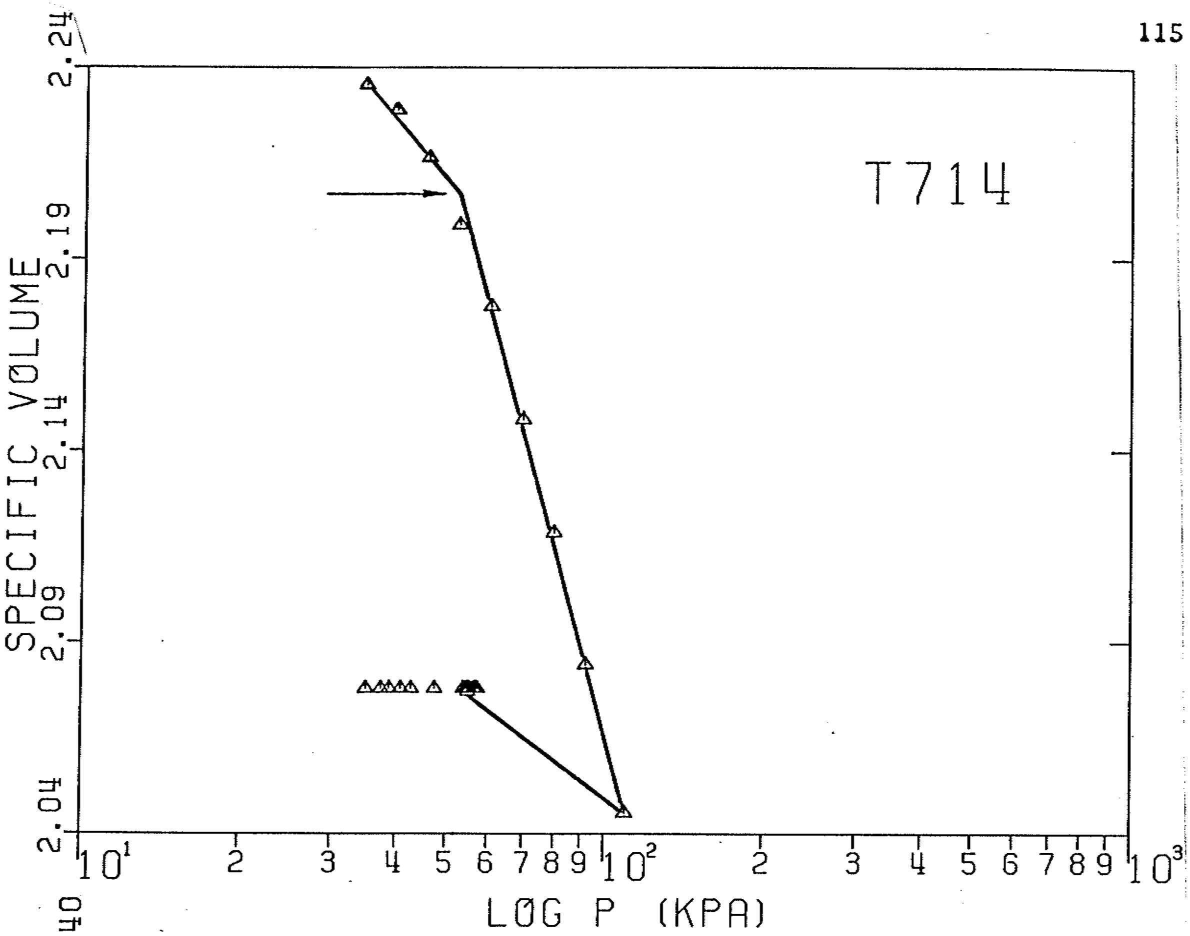


FIGURE 5.8a,b - TRIAXIAL CONSOLIDATION AND YIELD DETERMINATION log(p') vs V, T710, T712



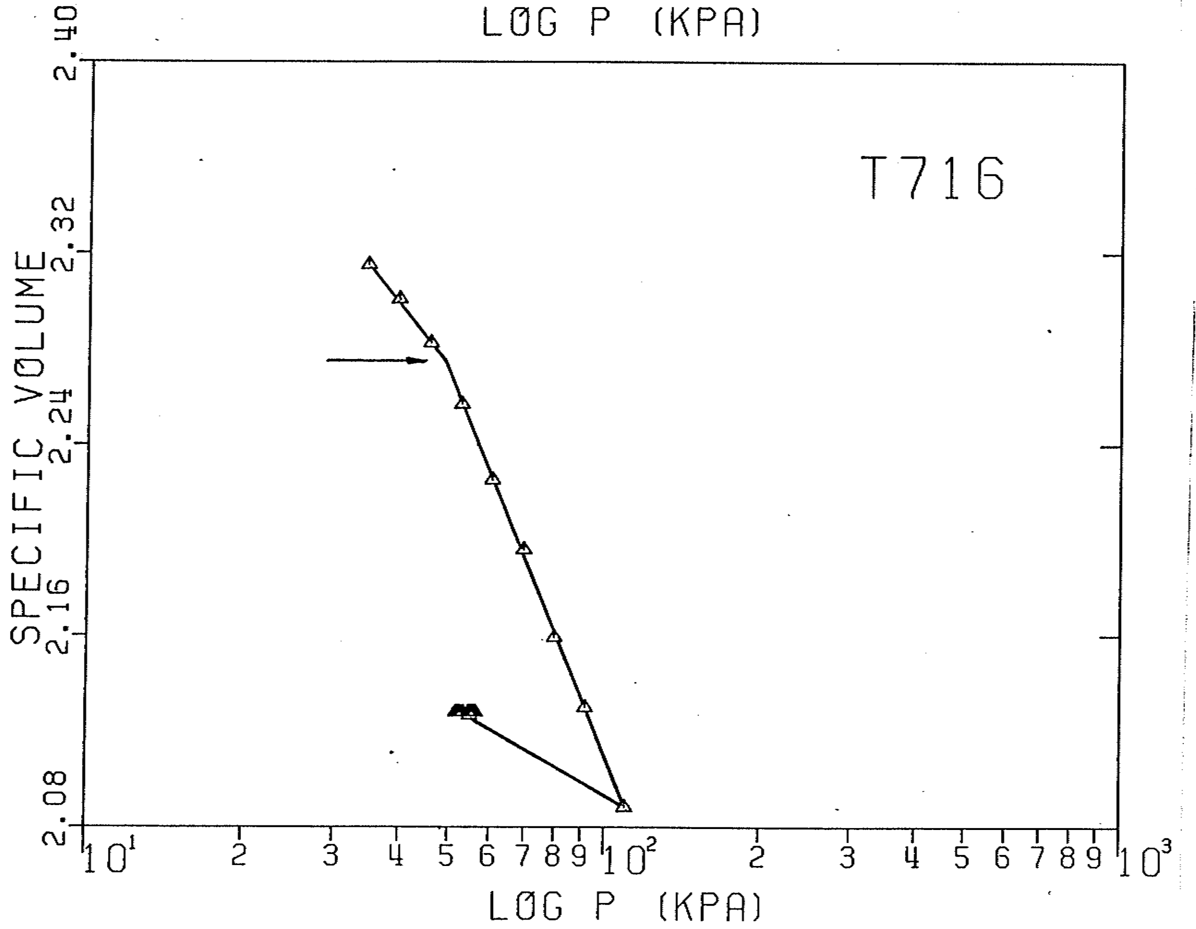
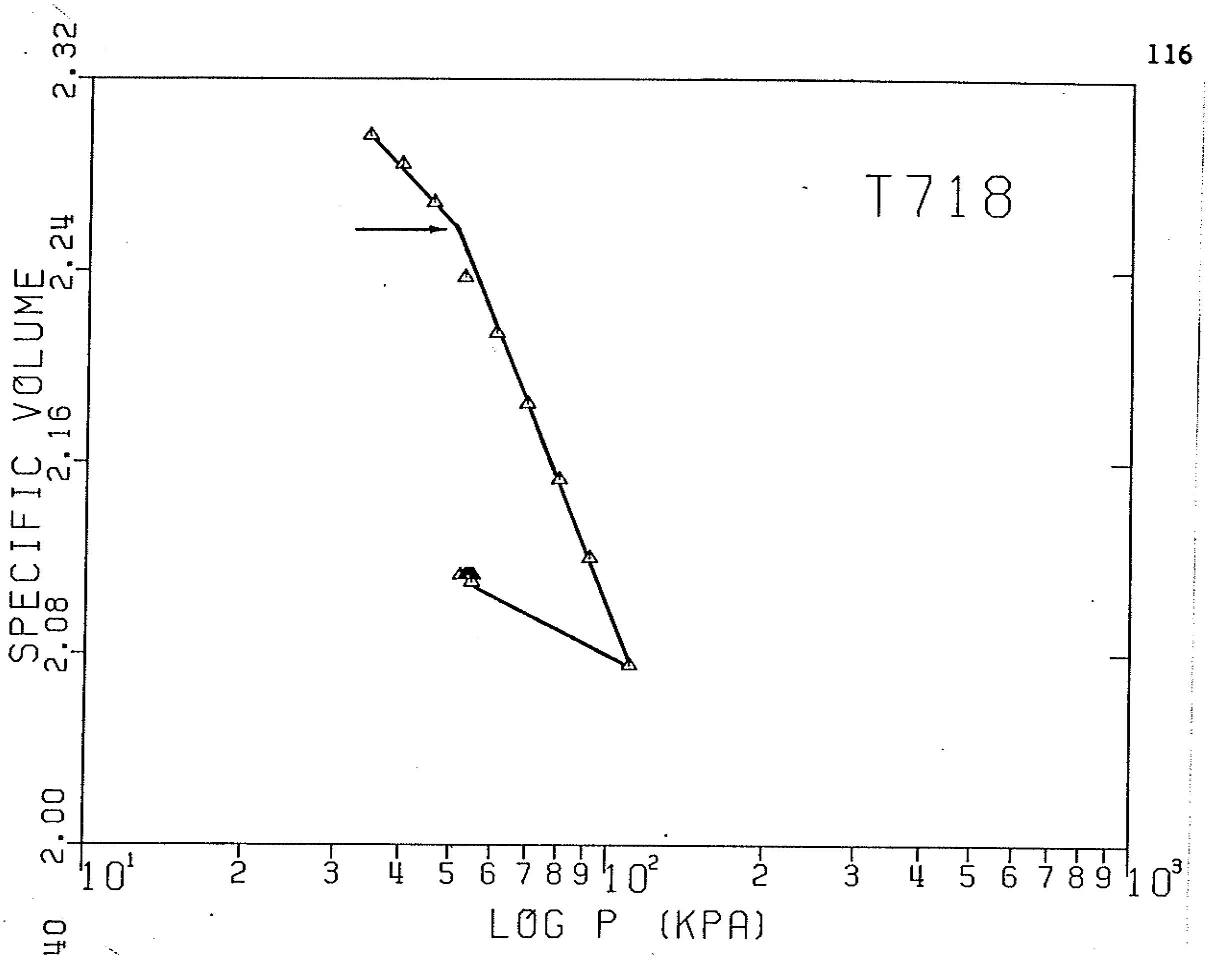


FIGURE 5.9a,b - TRIAXIAL CONSOLIDATION AND YIELD DETERMINATION
log(p') vs V, T714, T716



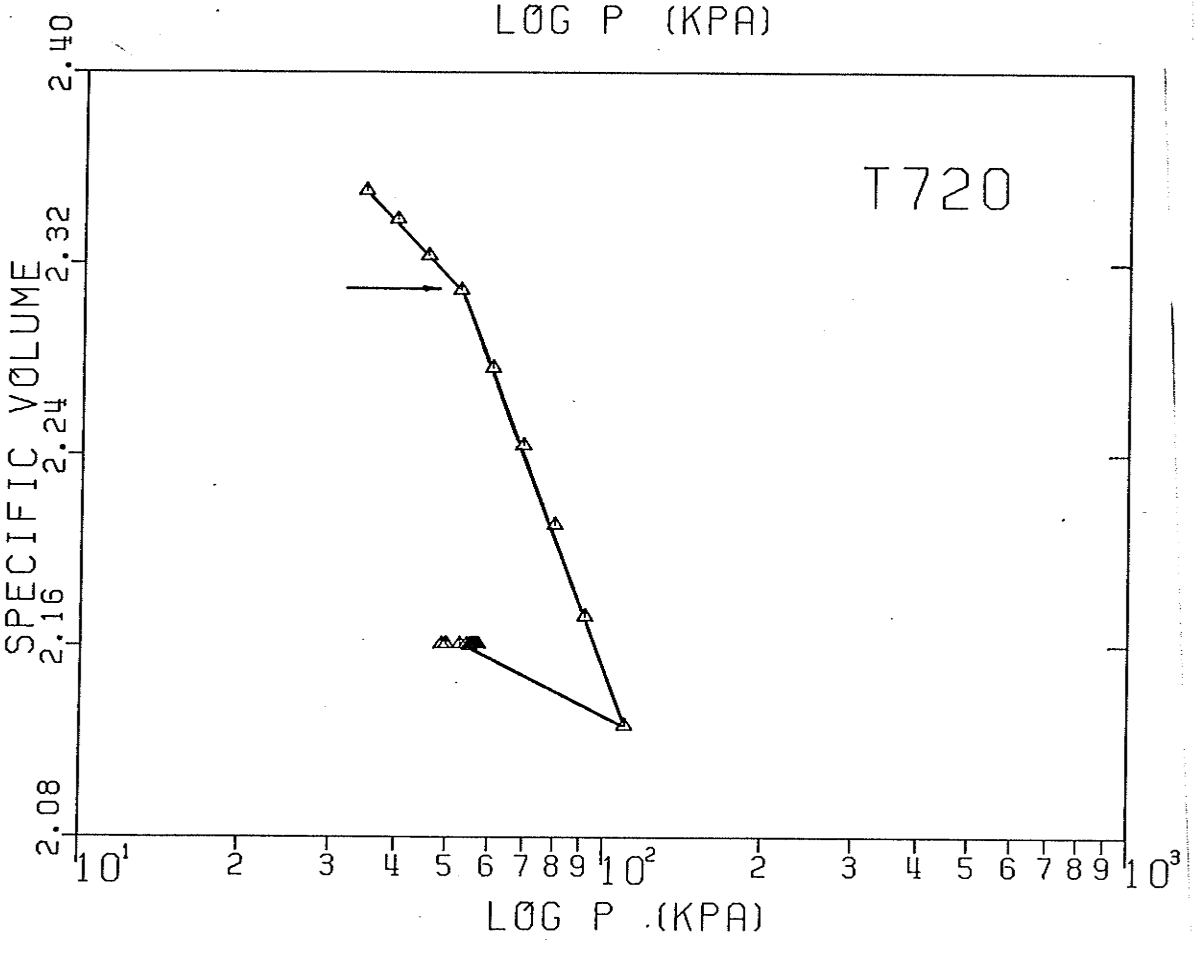


FIGURE 5.10a,b - TRIAXIAL CONSOLIDATION AND YIELD DETERMINATION
log(p') vs V, T718, T720

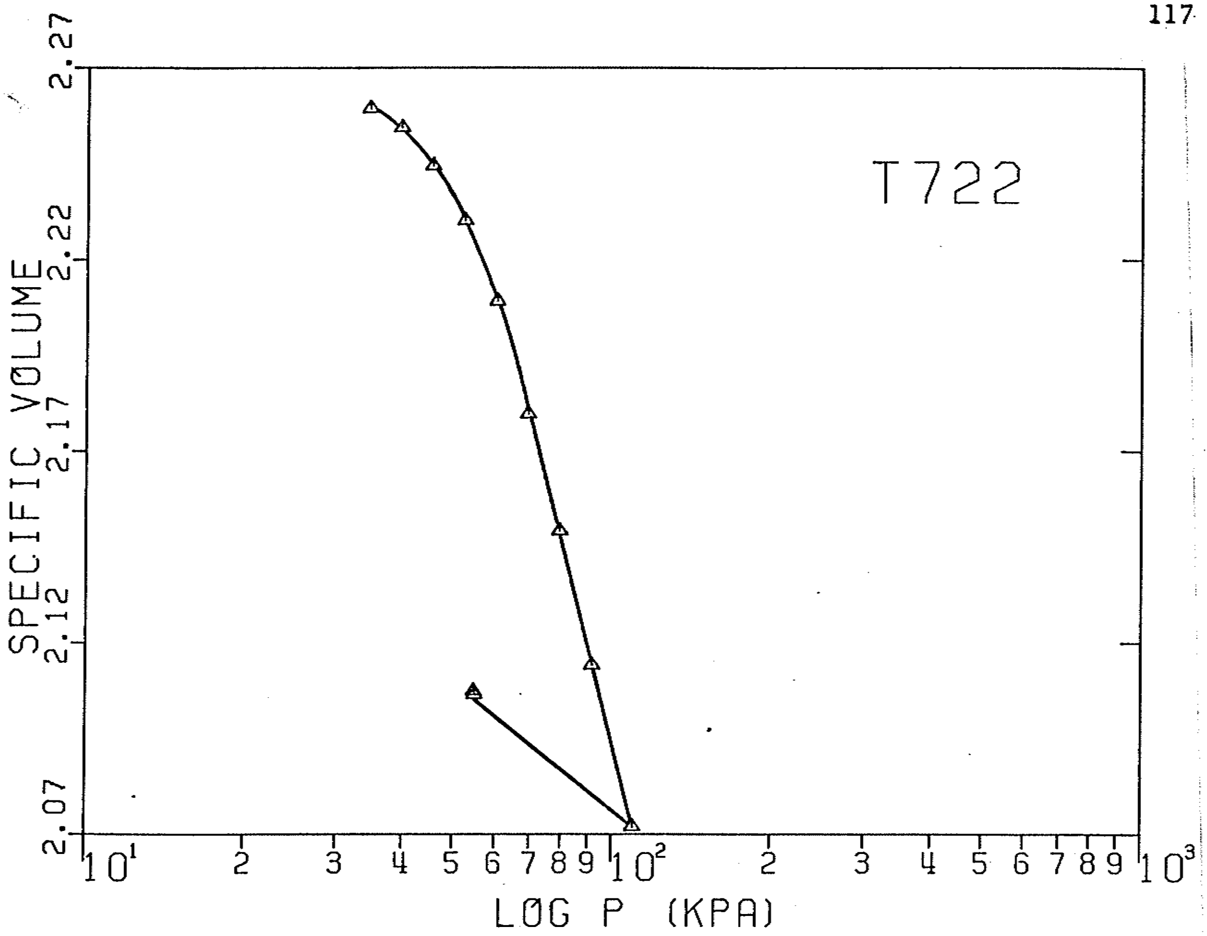


FIGURE 5.11 - TRIAXIAL CONSOLIDATION AND YIELD DETERMINATION
log (p') vs V, T722

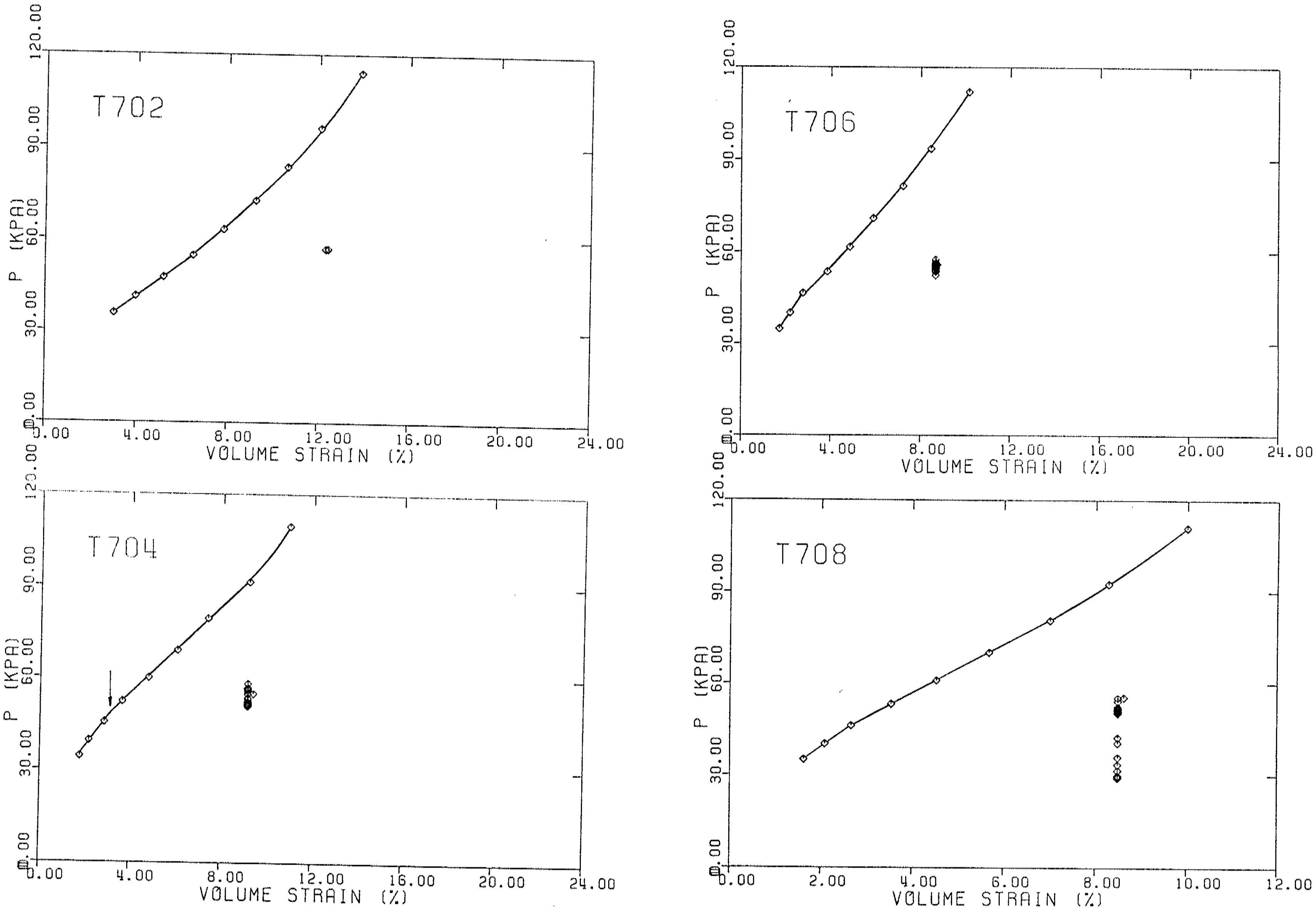


FIGURE 5.12a,b,c,d - YIELD DETERMINATION,
p' vs v, T702, T704, T706, T708

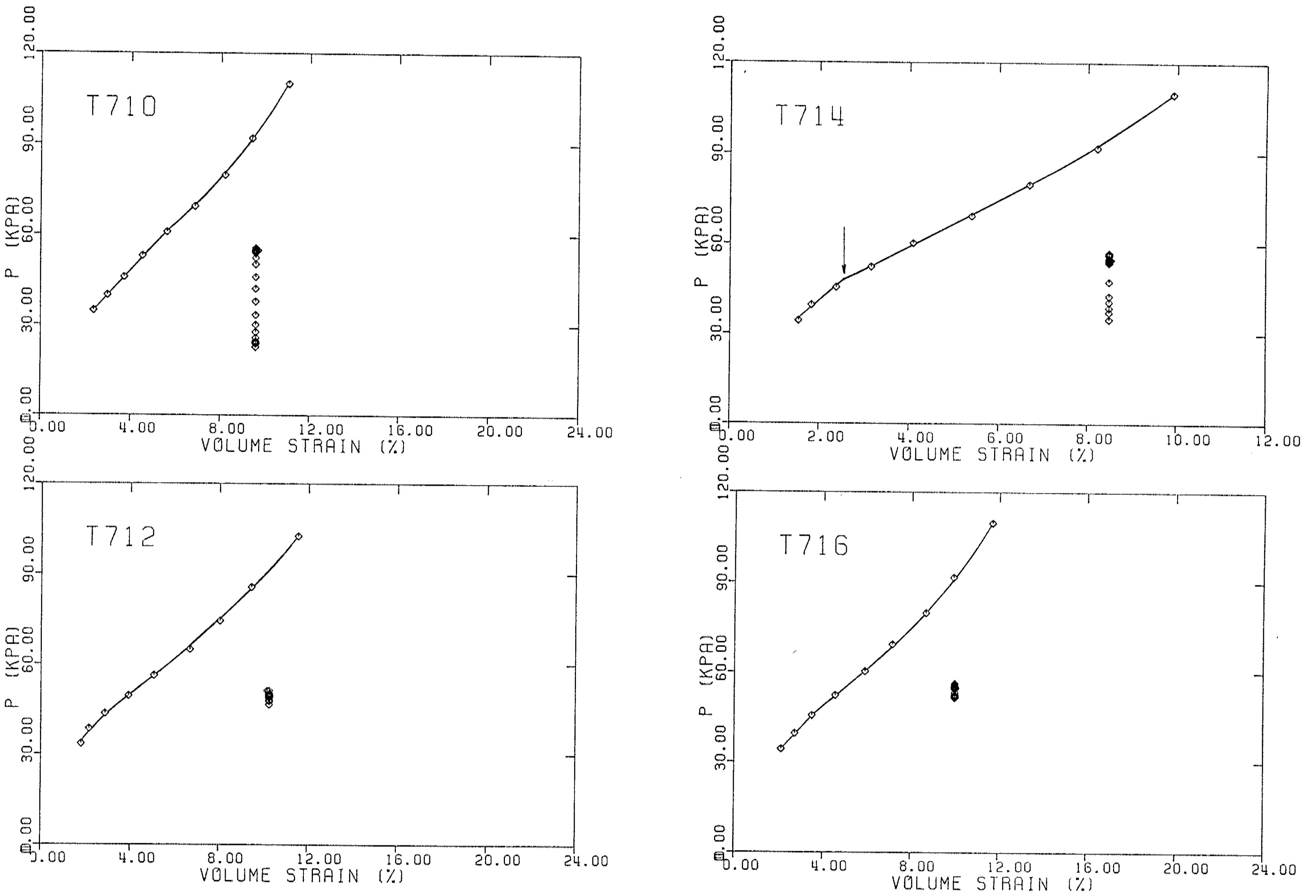


FIGURE 5.13a,b,c,d - YIELD DETERMINATION,
p' vs v, T710, T712, T714, T716

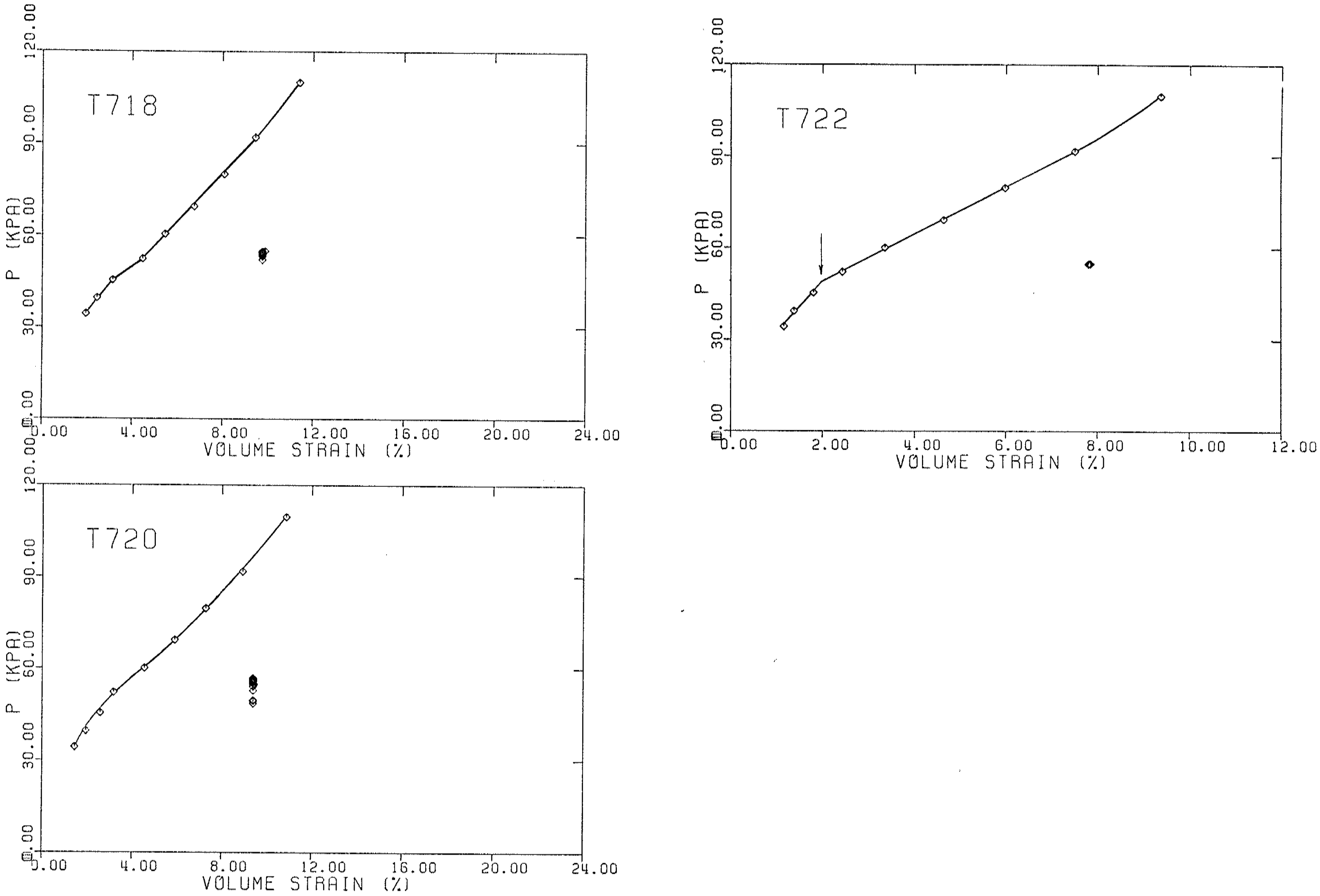


FIGURE 5.14a,b,c - YIELD DETERMINATION,
p' vs v, T718, T720, T722

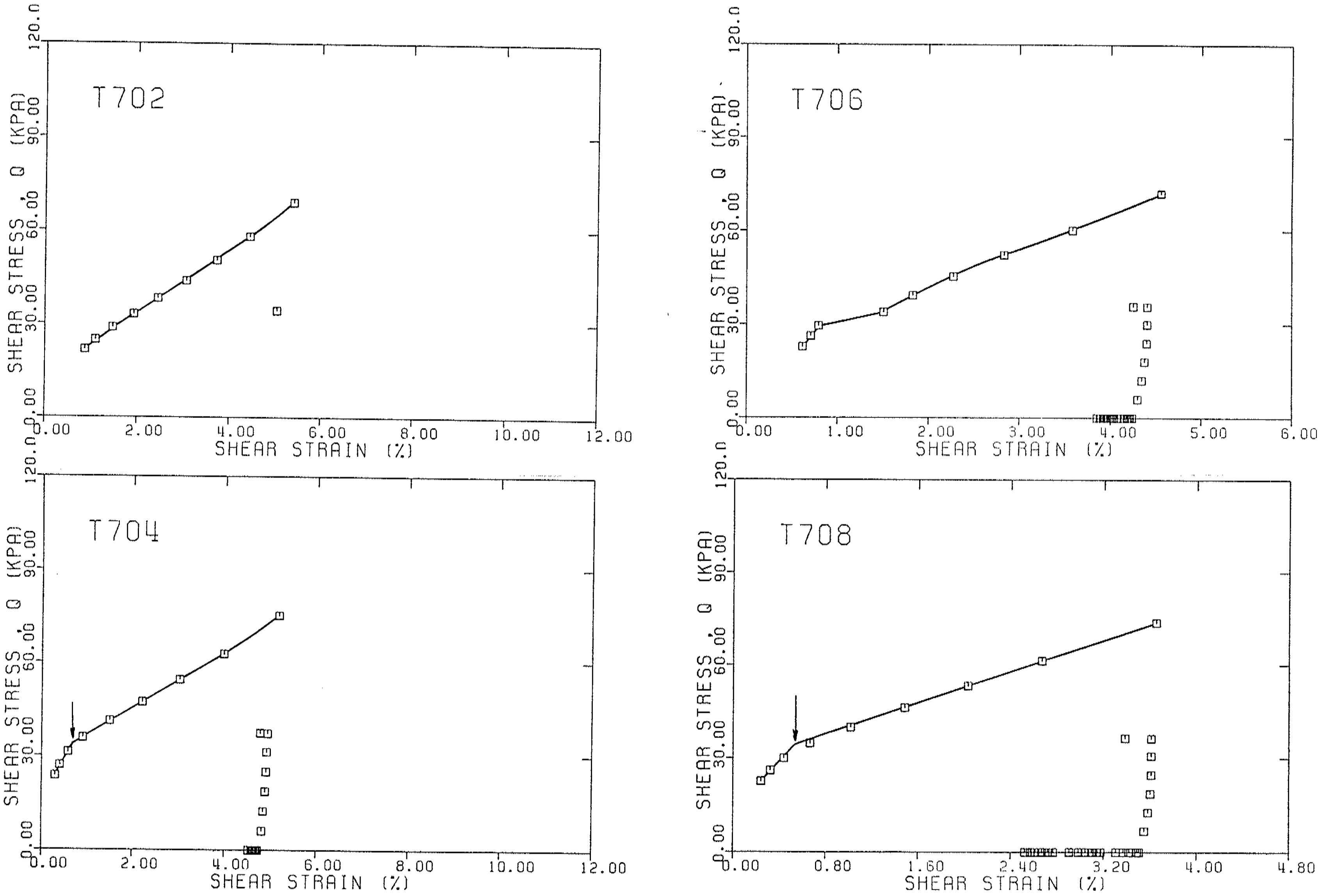


FIGURE 5.15a,b,c,d - YIELD DETERMINATION,
q vs ε, T702, T704, T706, T708

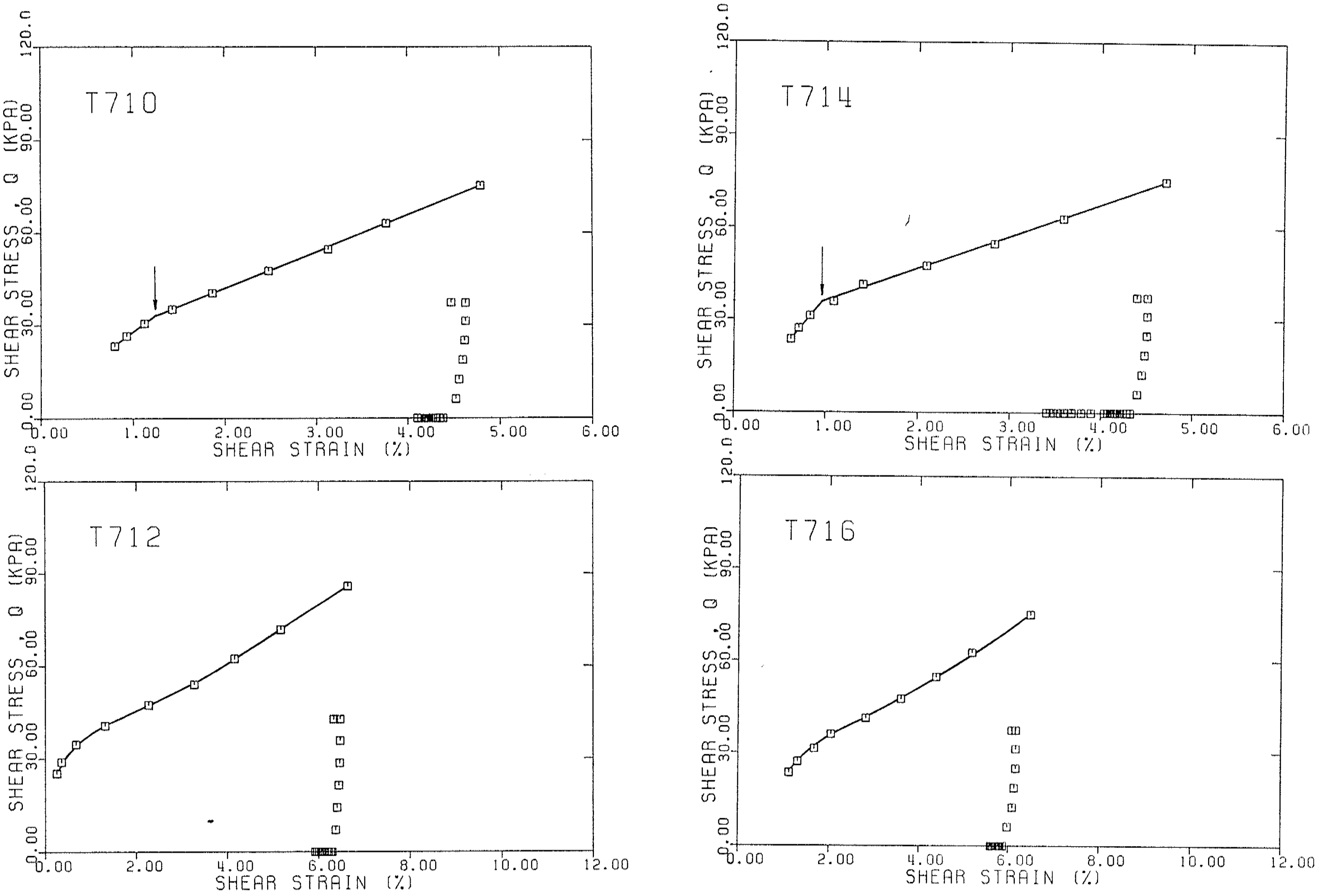


FIGURE 5.16a,b,c,d - YIELD DETERMINATION,
q vs ε, T710, T712, T714, T716

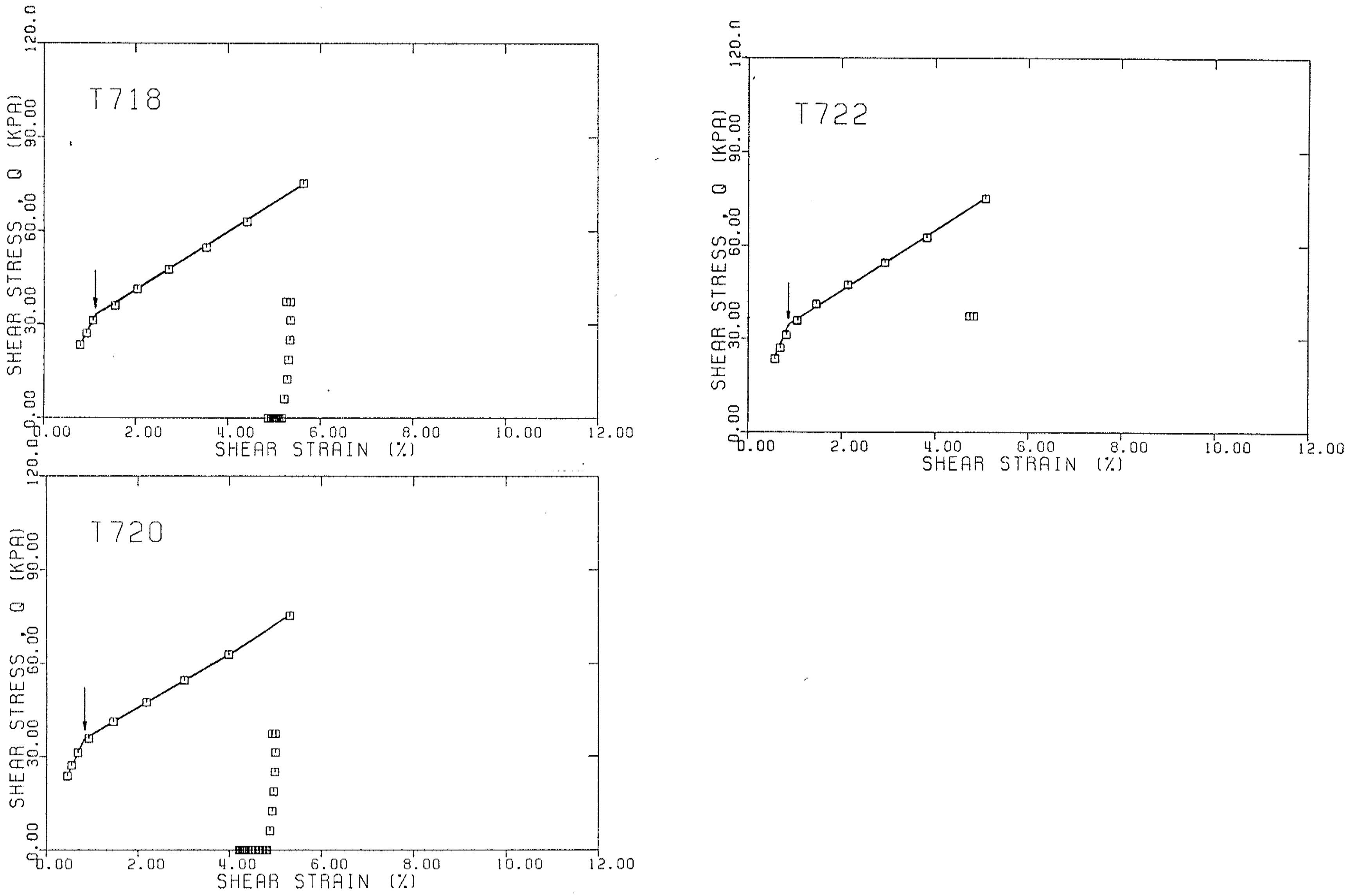


FIGURE 5.17a,b,c - YIELD DETERMINATION,
q vs ε, T718, T720, T722

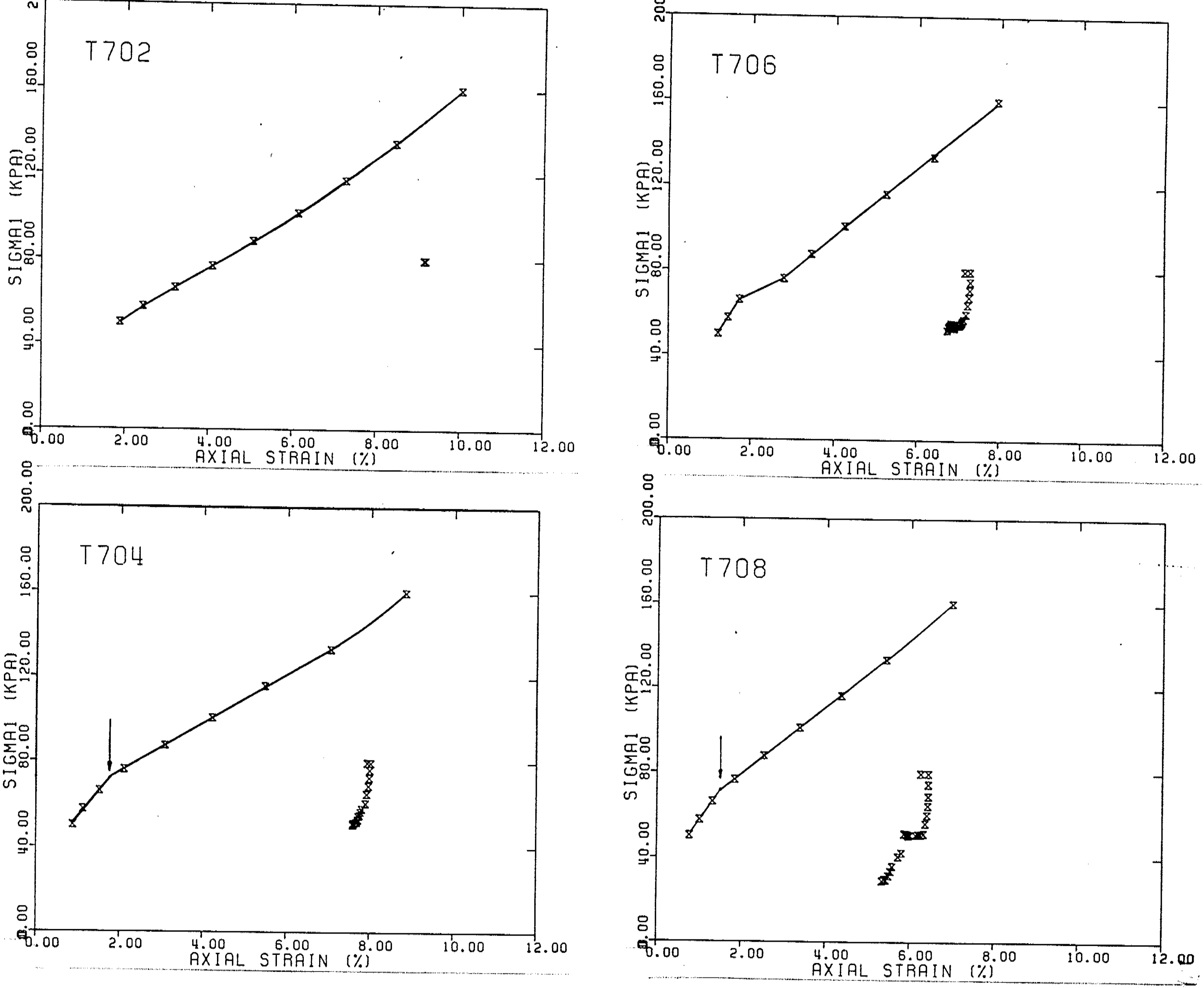


FIGURE 5.18a,b,c,d - YIELD DETERMINATION,
σ_1 vs ε_1 , T702, T704, T706, T708

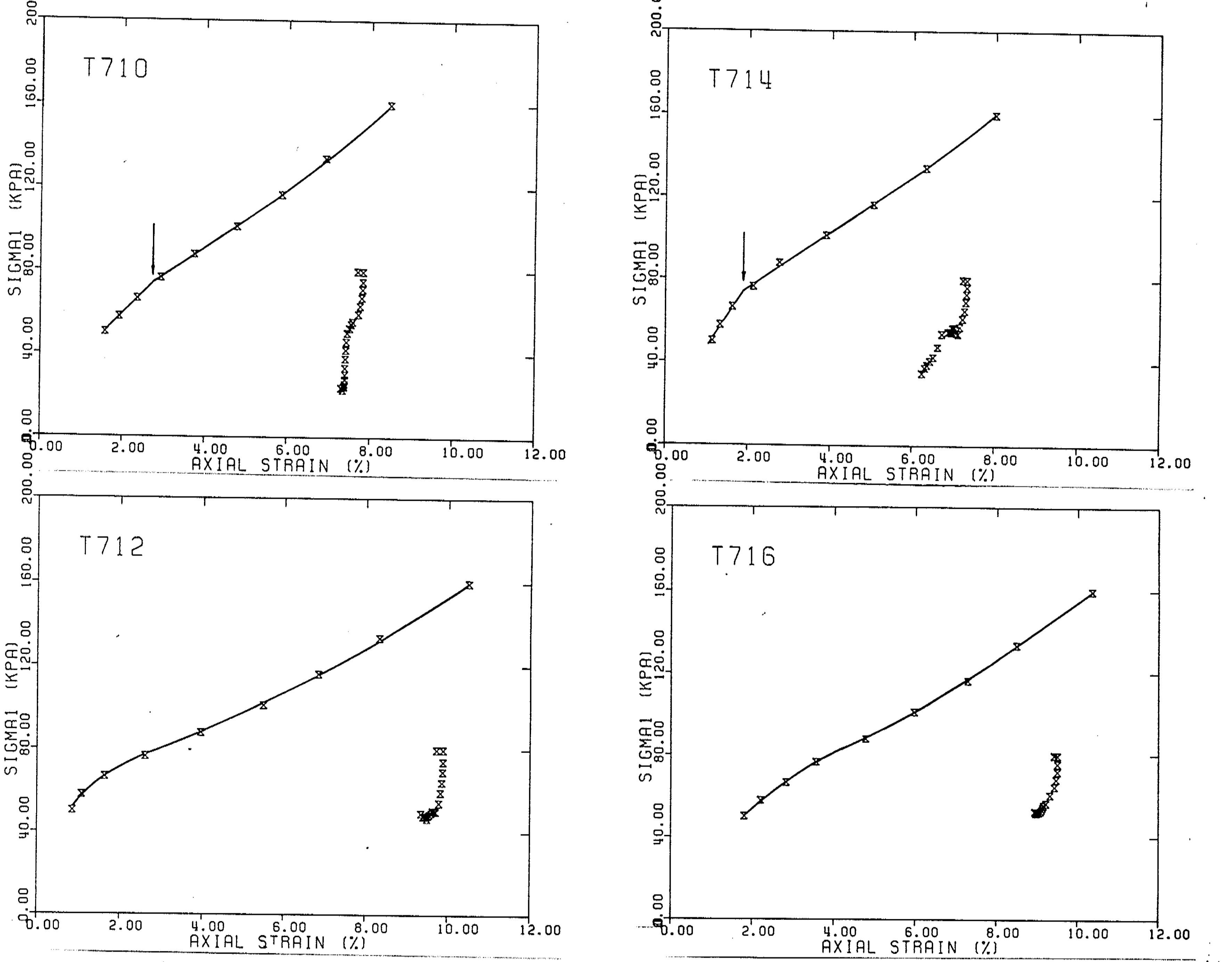


FIGURE 5.19a,b,c,d - YIELD DETERMINATION,
σ_1 vs ε_1, T710, T712, T714, T716

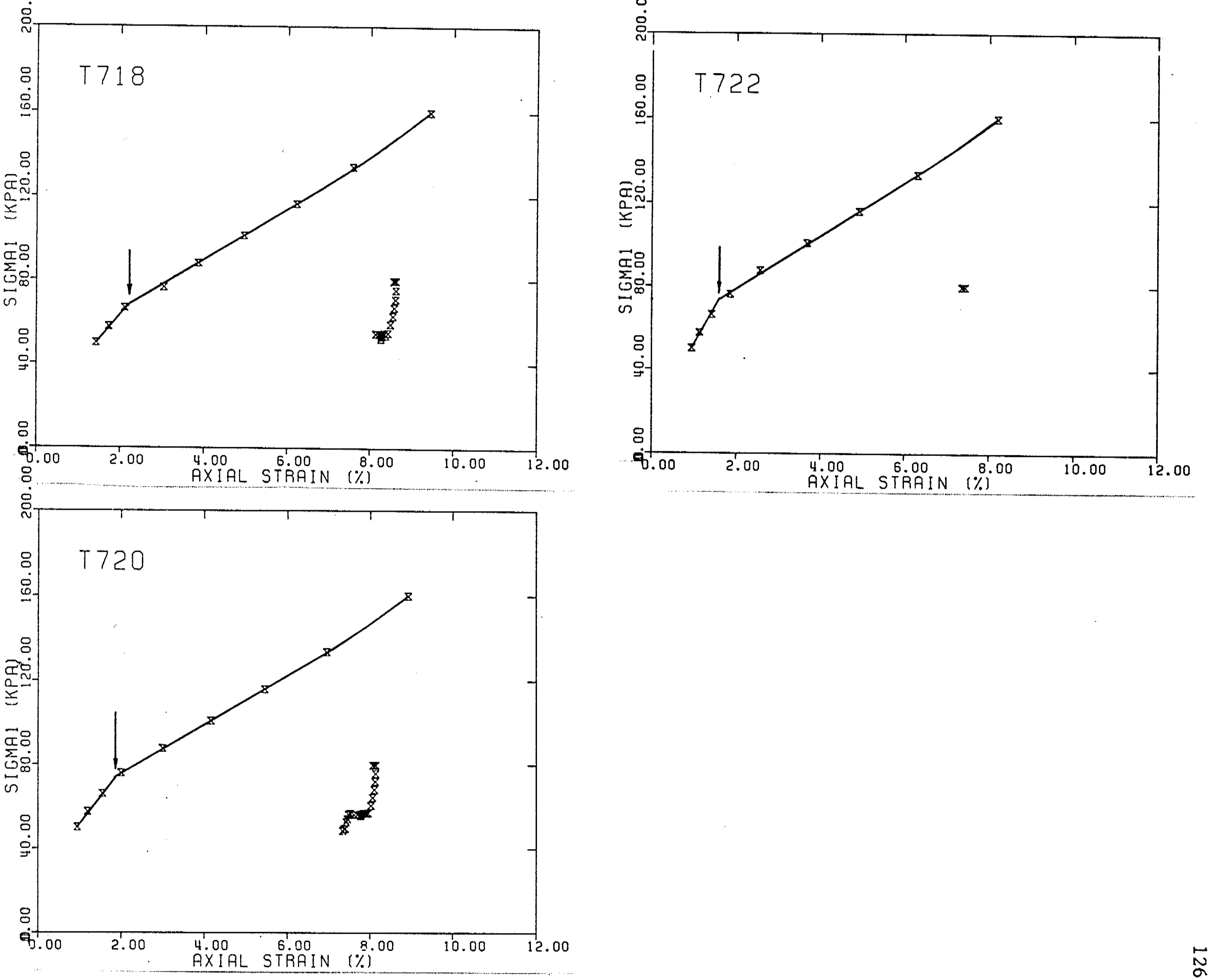


FIGURE 5.20a,b,c - YIELD DETERMINATION,
σ_1 vs ε_1, T718, T720, T722

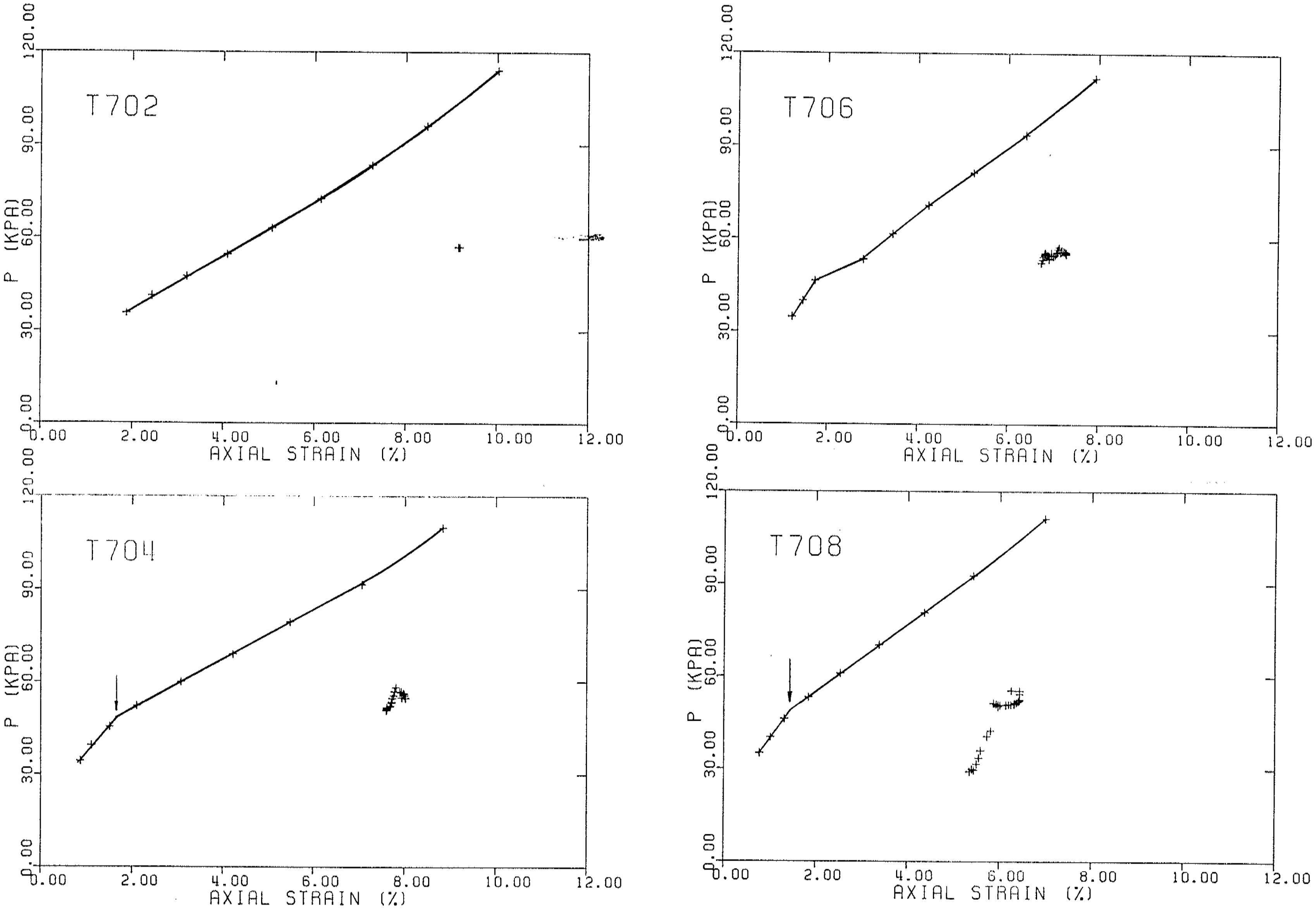


FIGURE 5.21a,b,c,d - YIELD DETERMINATION,
p' vs ε_1, T702, T704, T706, T708

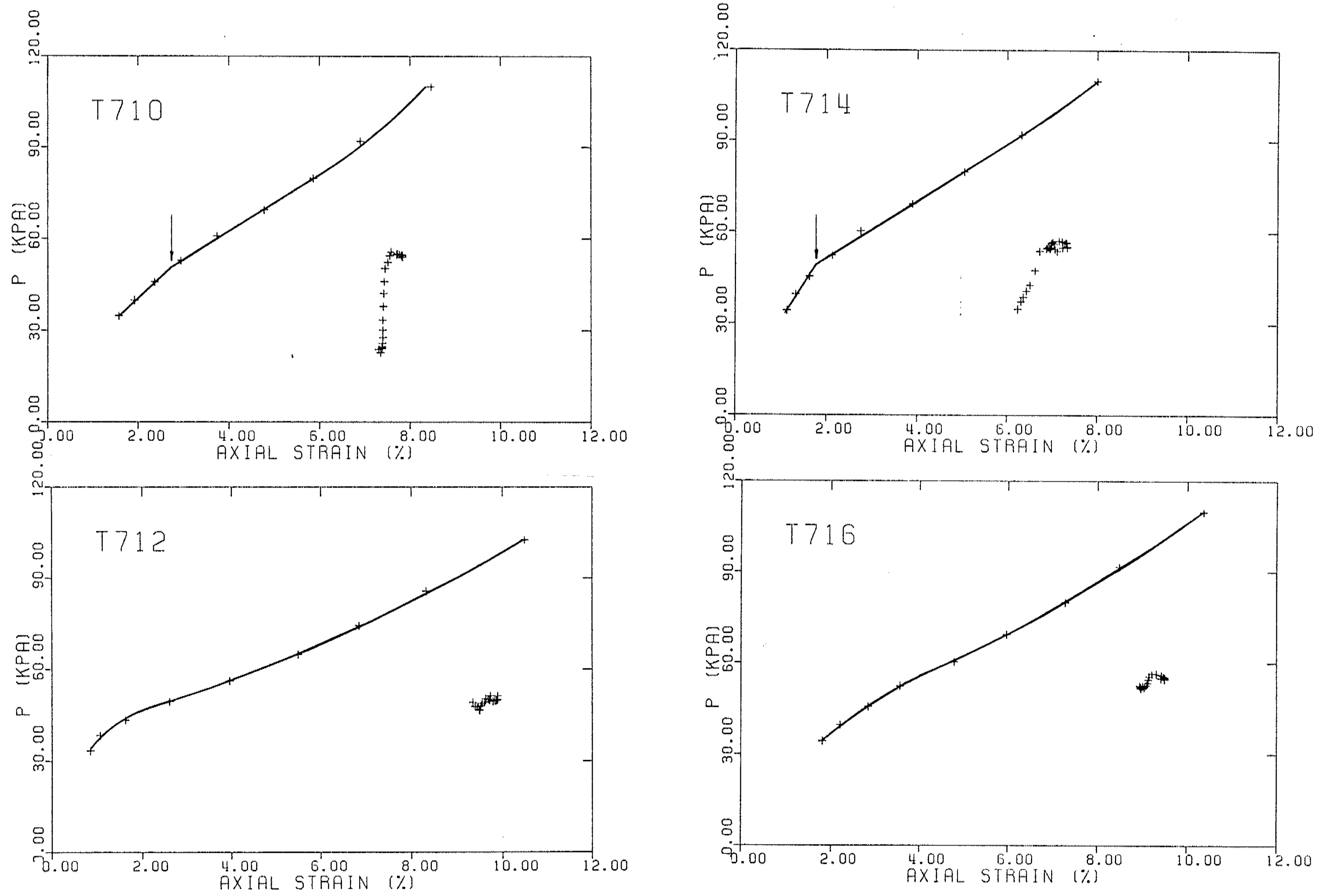


FIGURE 5.22a,b,c,d - YIELD DETERMINATION,
p' vs ε_1, T710, T712, T714, T716

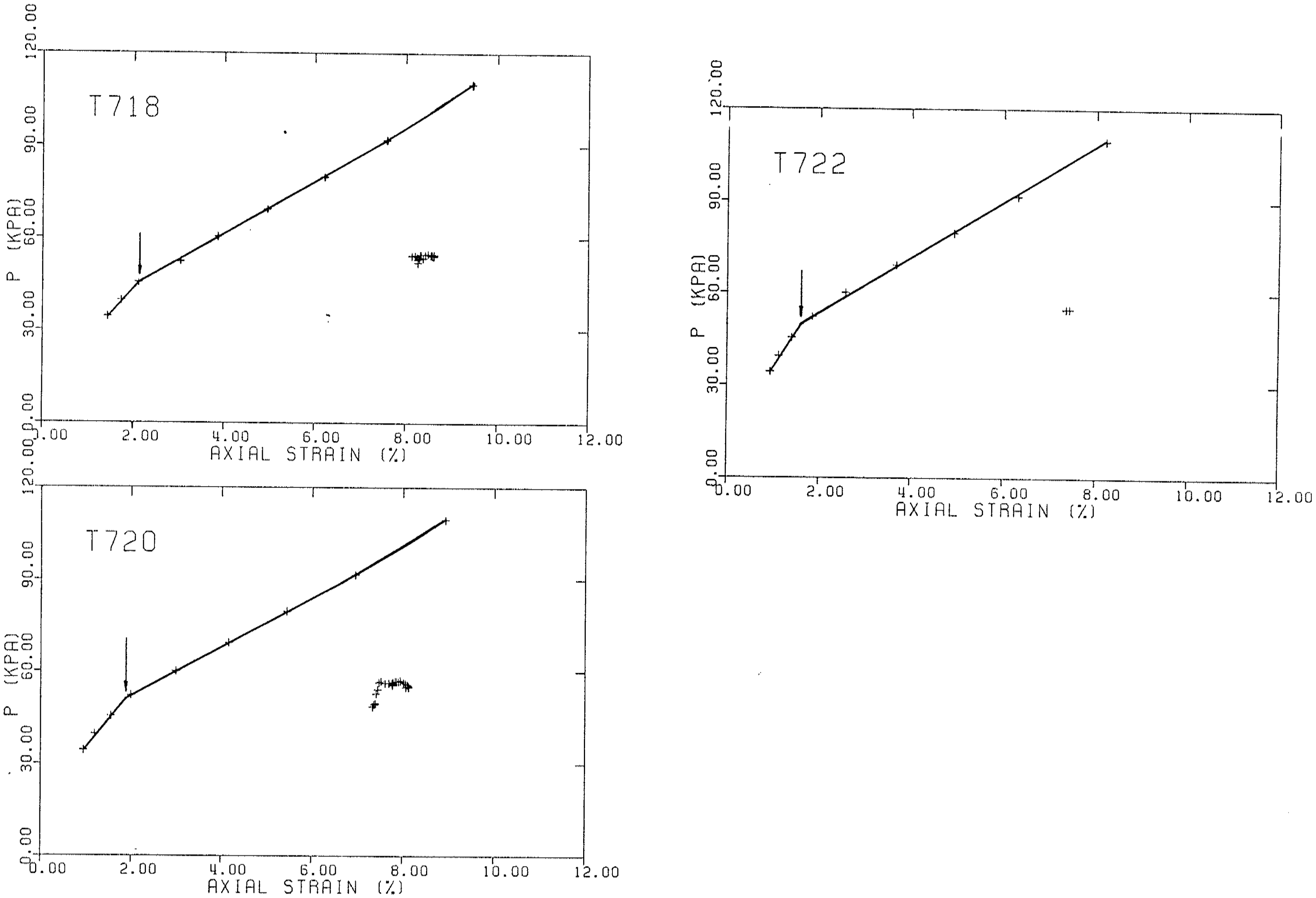


FIGURE 5.23a,b,c - YIELD DETERMINATION,
p' vs ε_1, T718, T720, T722

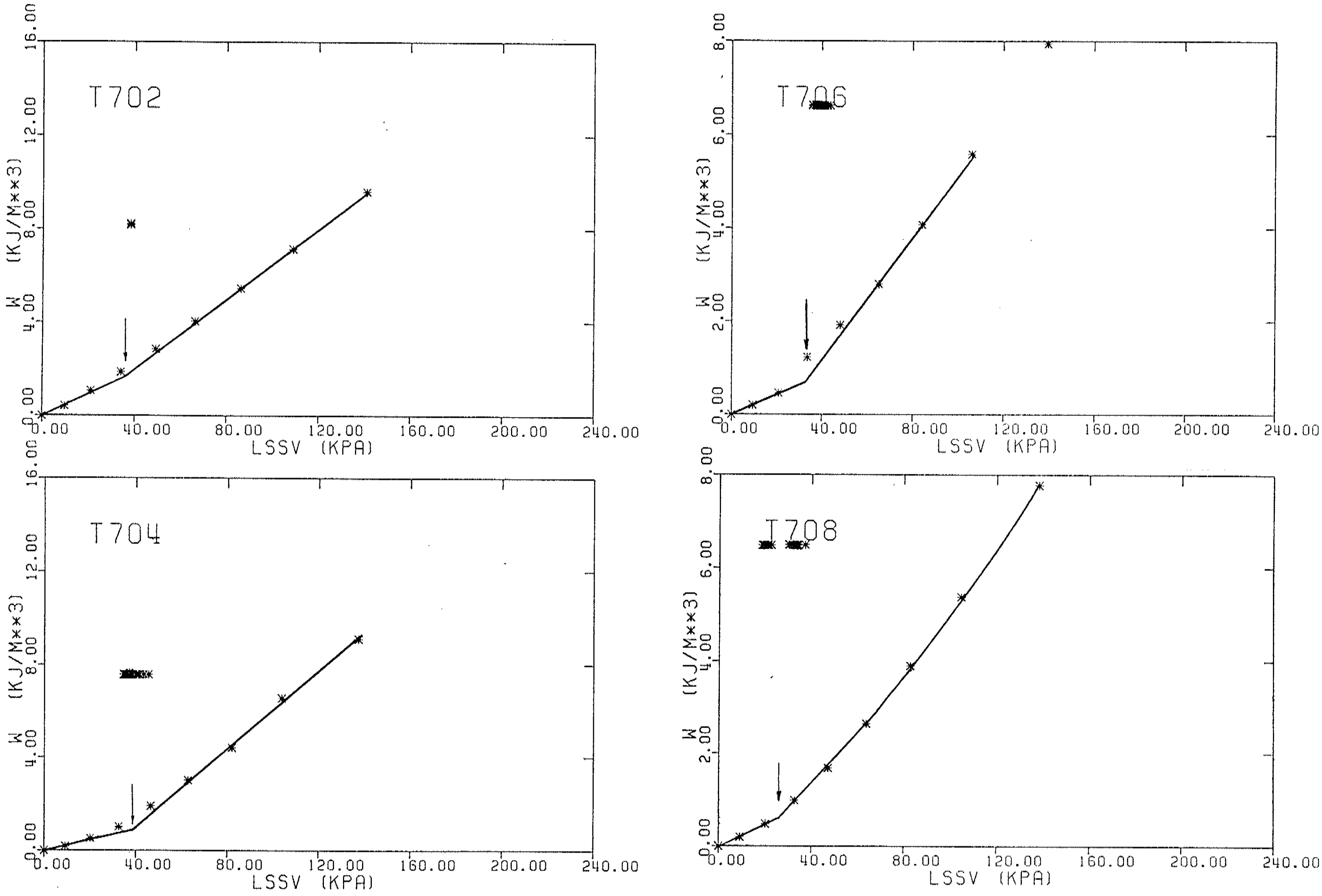


FIGURE 5.24a,b,c,d - YIELD DETERMINATION,
W vs LSSV, T702, T704, T706, T708

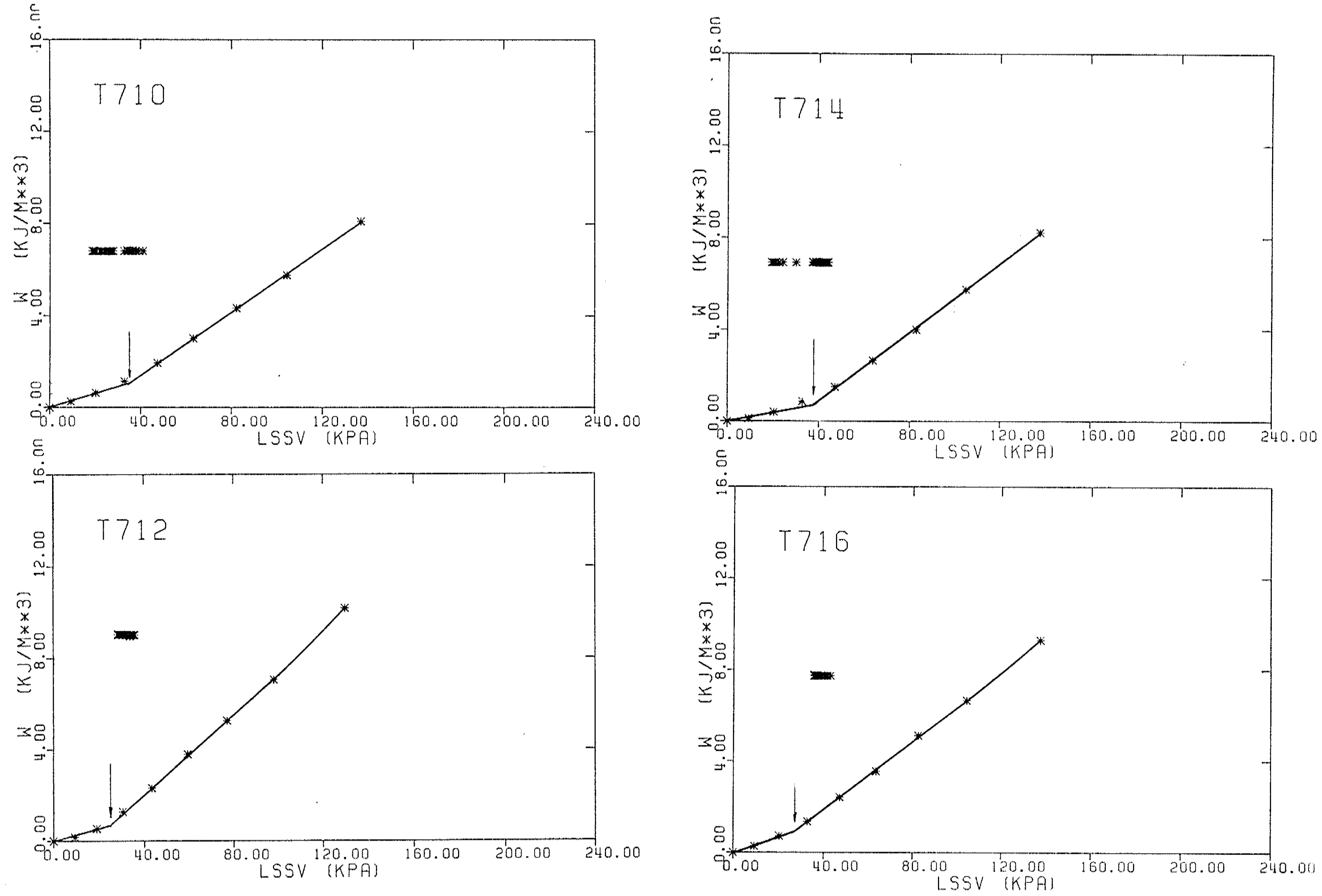


FIGURE 5.25a,b,c,d - YIELD DETERMINATION,
W vs LSSV, T710, T712, T714, T716

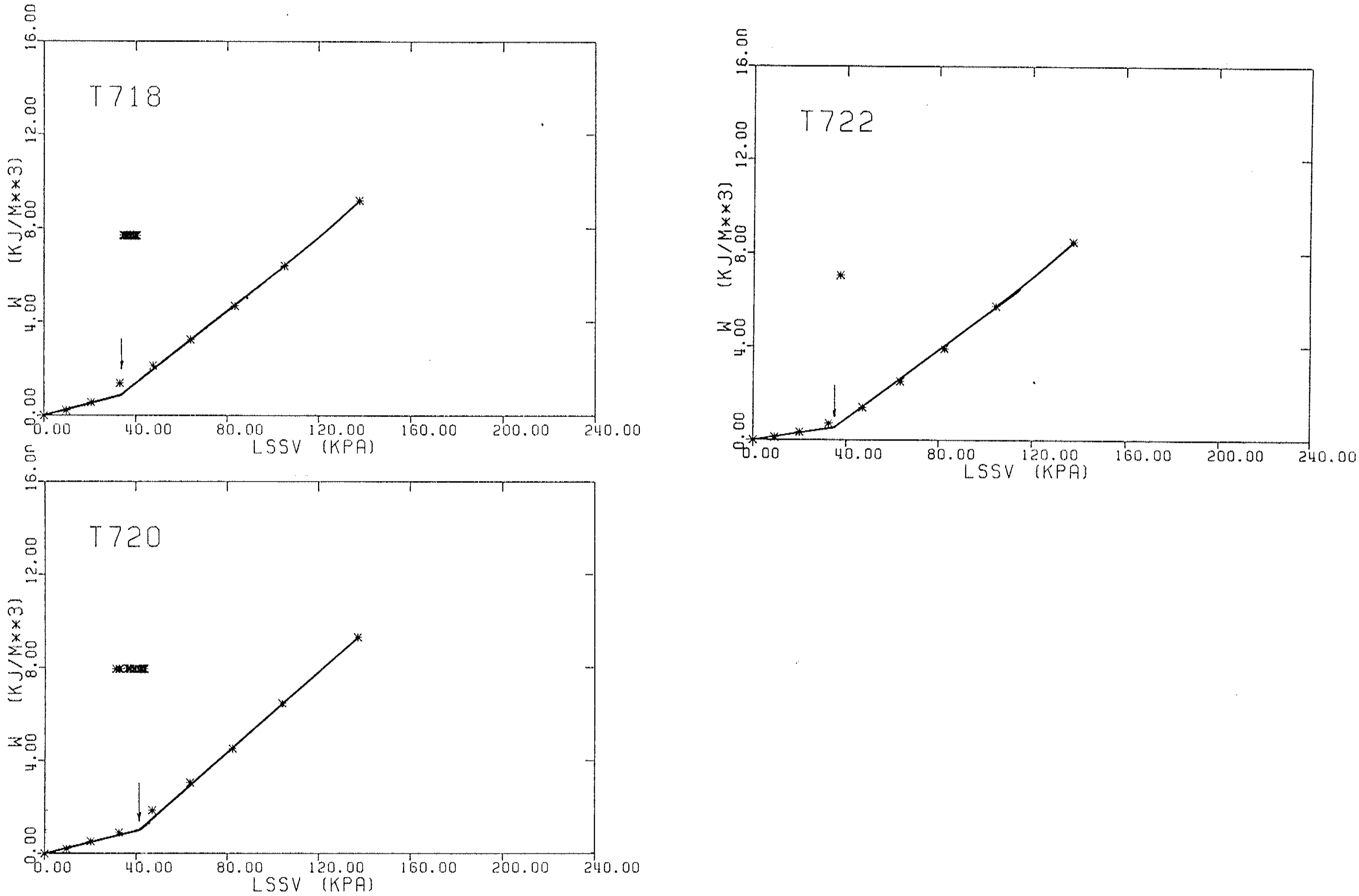


FIGURE 5.26a,b,c - YIELD DETERMINATION,
W vs LSSV, T718, T720, T722

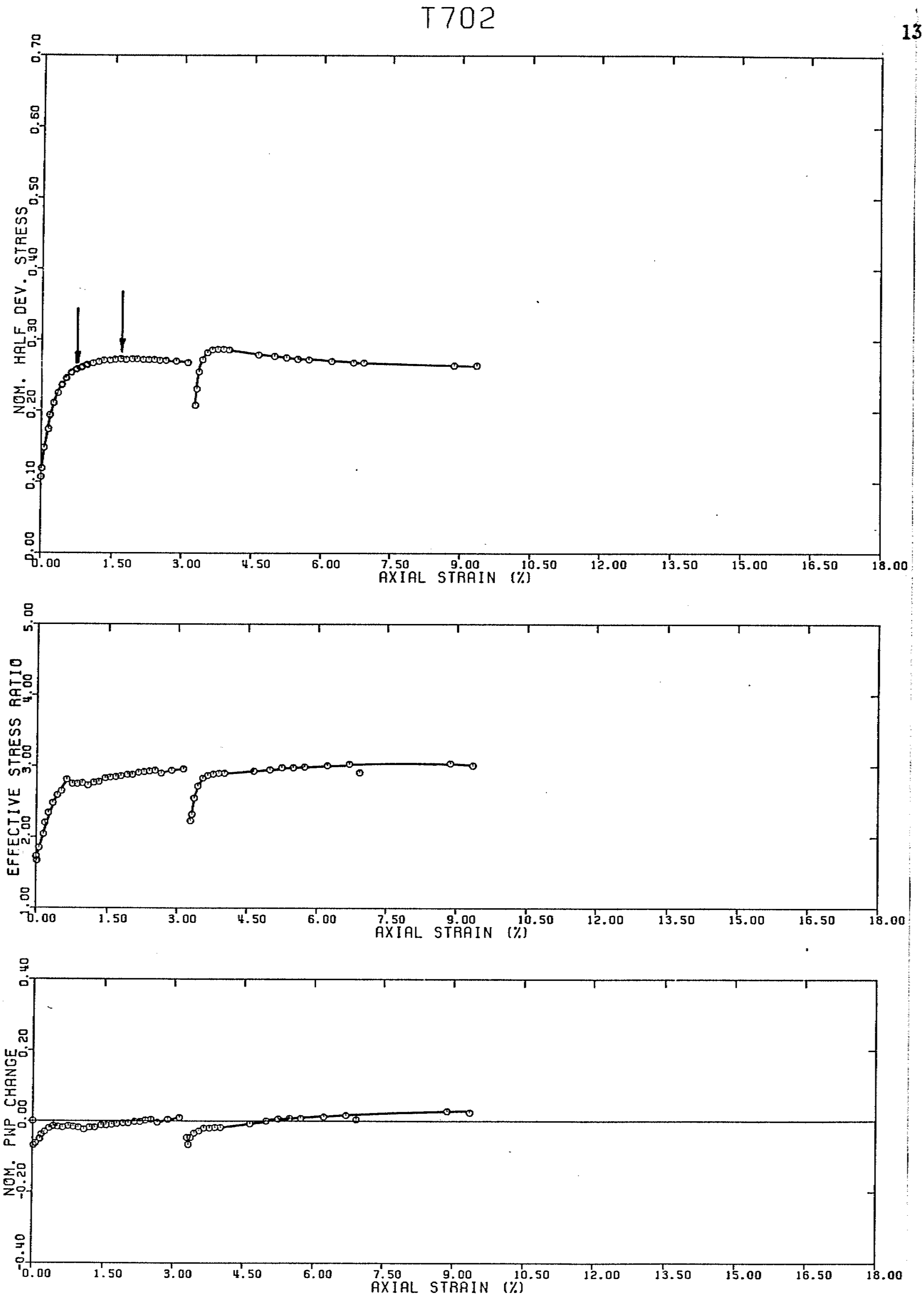


FIGURE 6.1 - UNDRAINED STRESS-STRAIN POREWATER PRESSURE RESULTS, T702

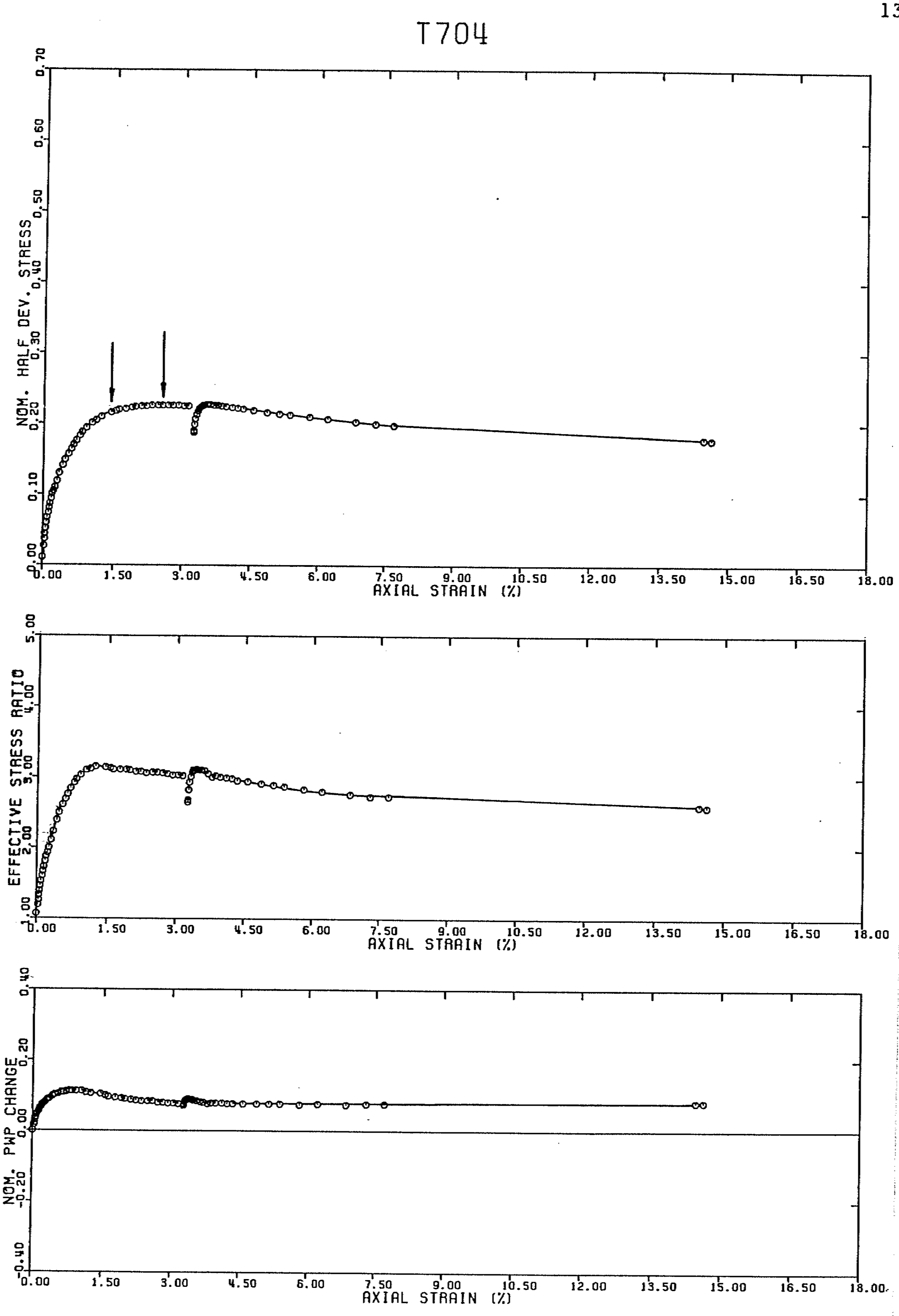


FIGURE 6.2 - UNDRAINED STRESS-STRAIN POREWATER PRESSURE RESULTS, T704

T706

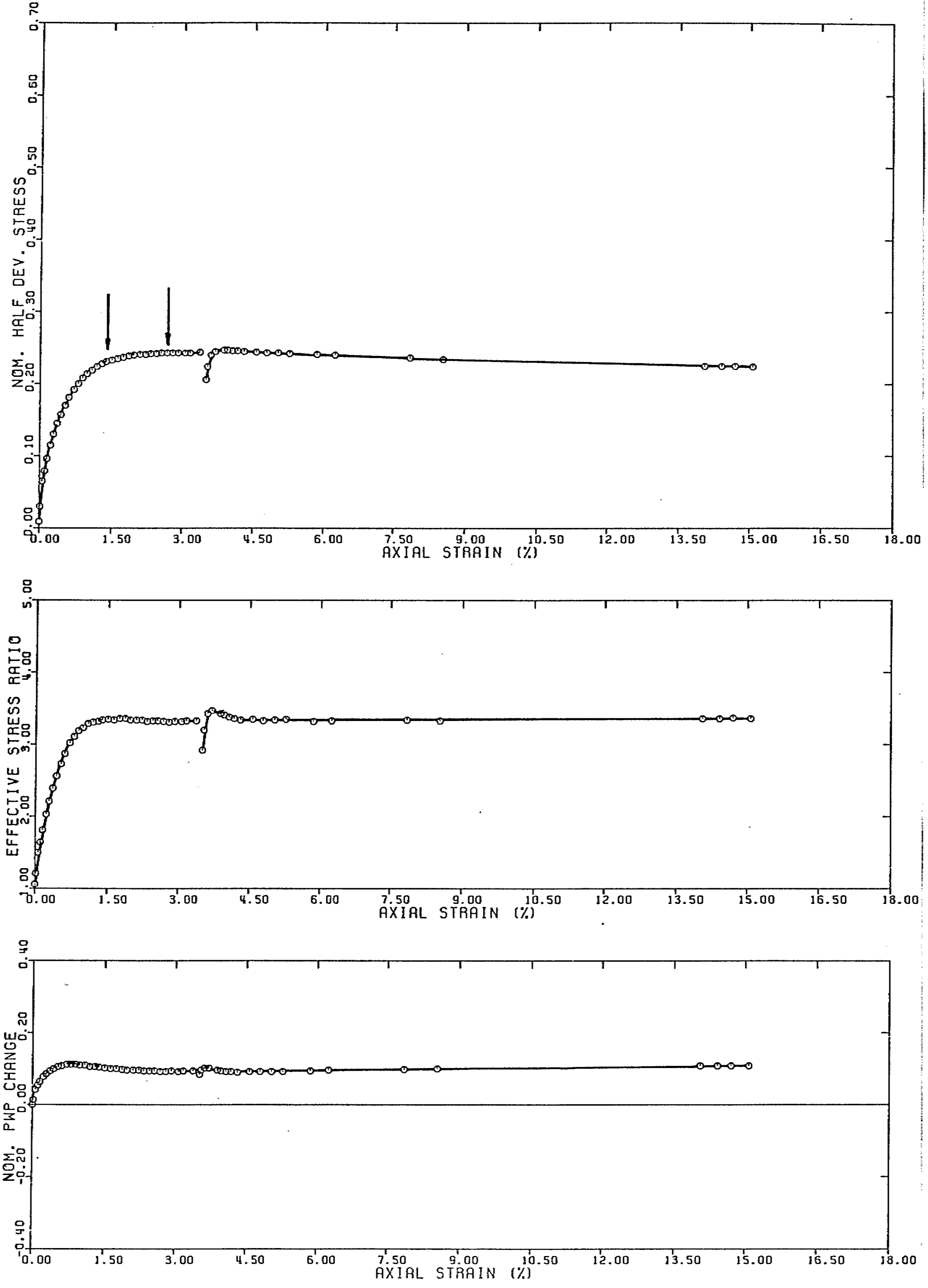


FIGURE 6.3 - UNDRAINED STRESS-STRAIN POREWATER PRESSURE RESULTS, T706

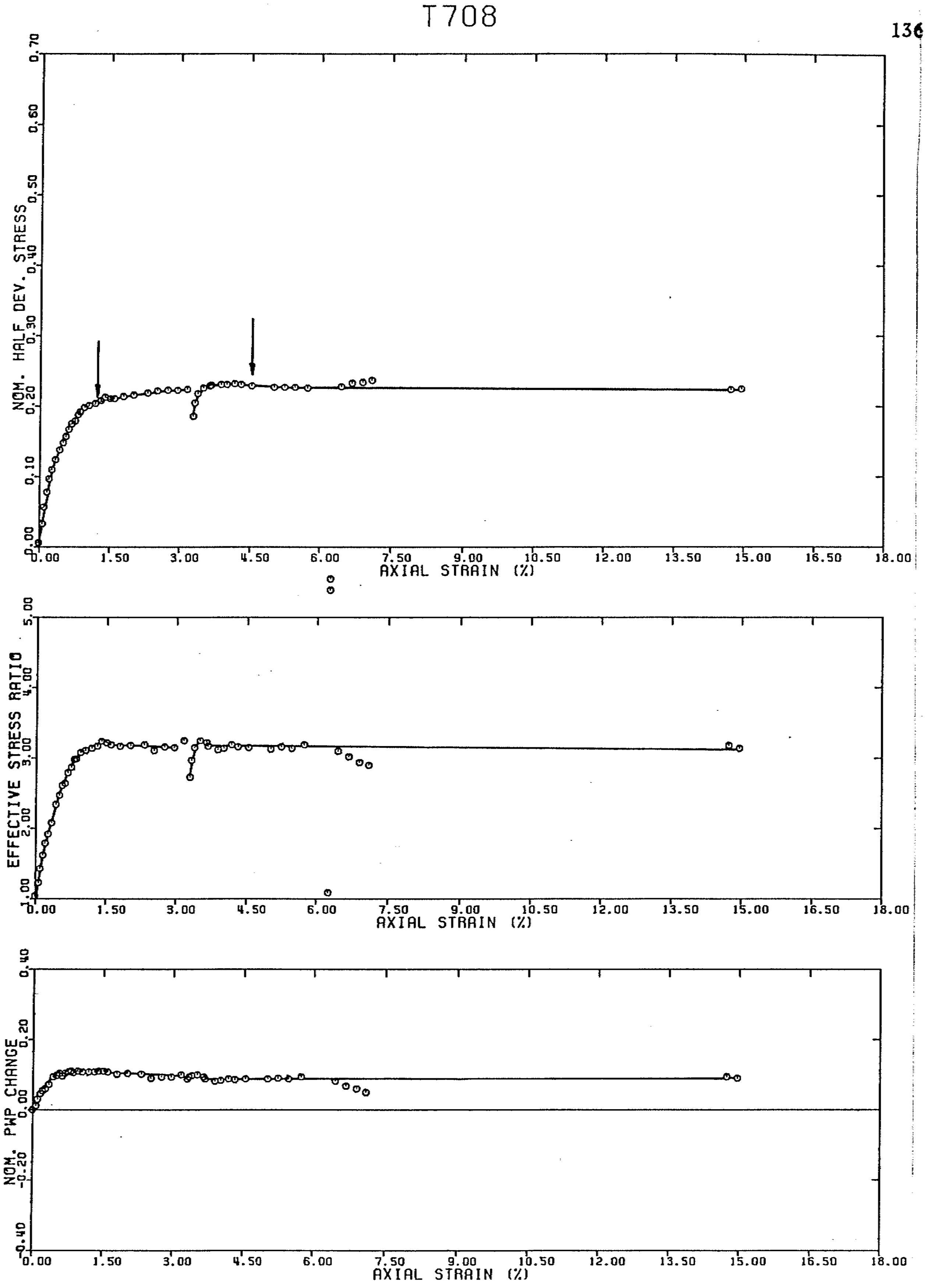


FIGURE 6.4 - UNDRAINED STRESS-STRAIN POREWATER PRESSURE RESULTS, T708

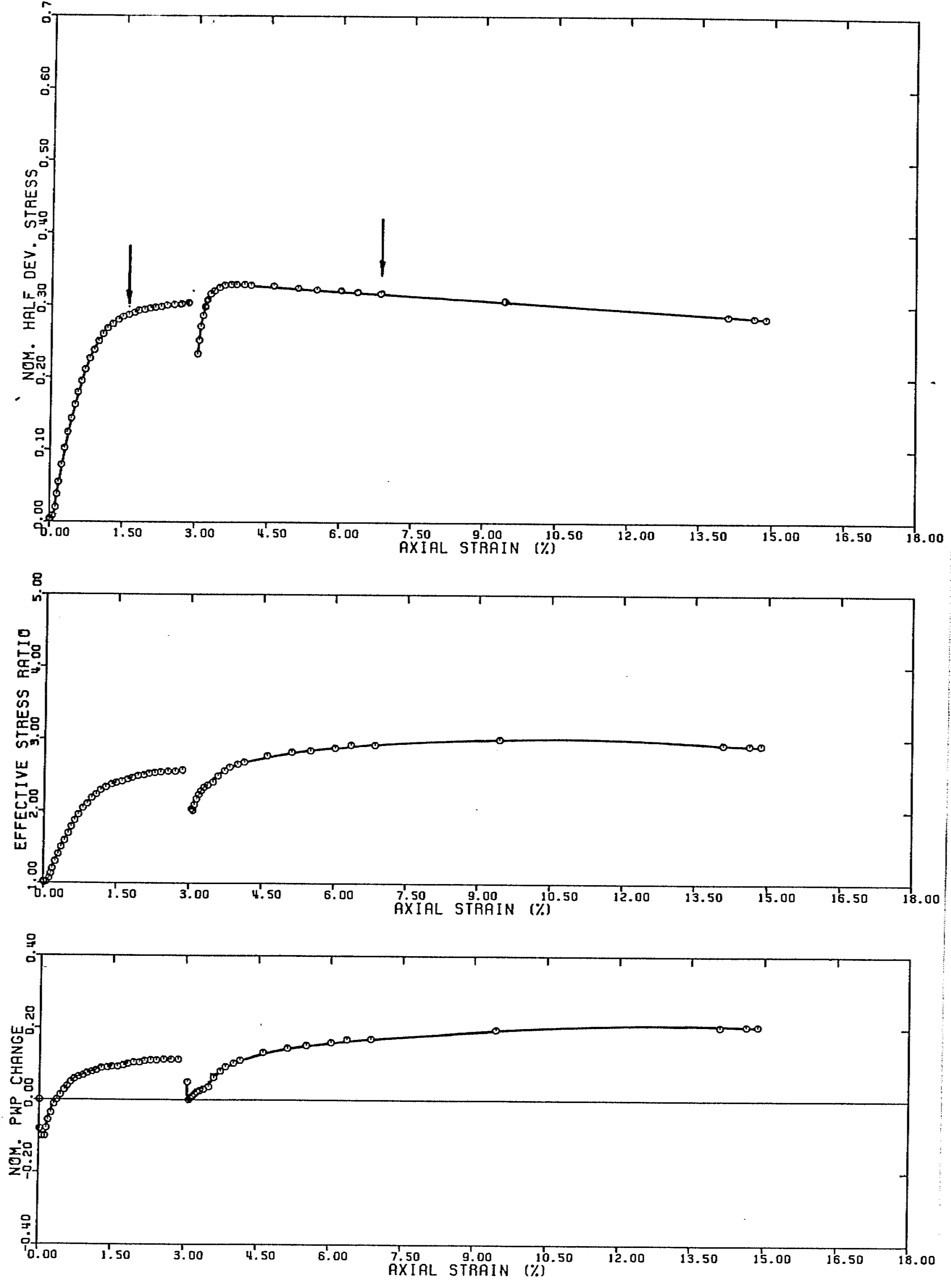

T710

FIGURE 6.5 - UNDRAINED STRESS-STRAIN POREWATER PRESSURE RESULTS, T710

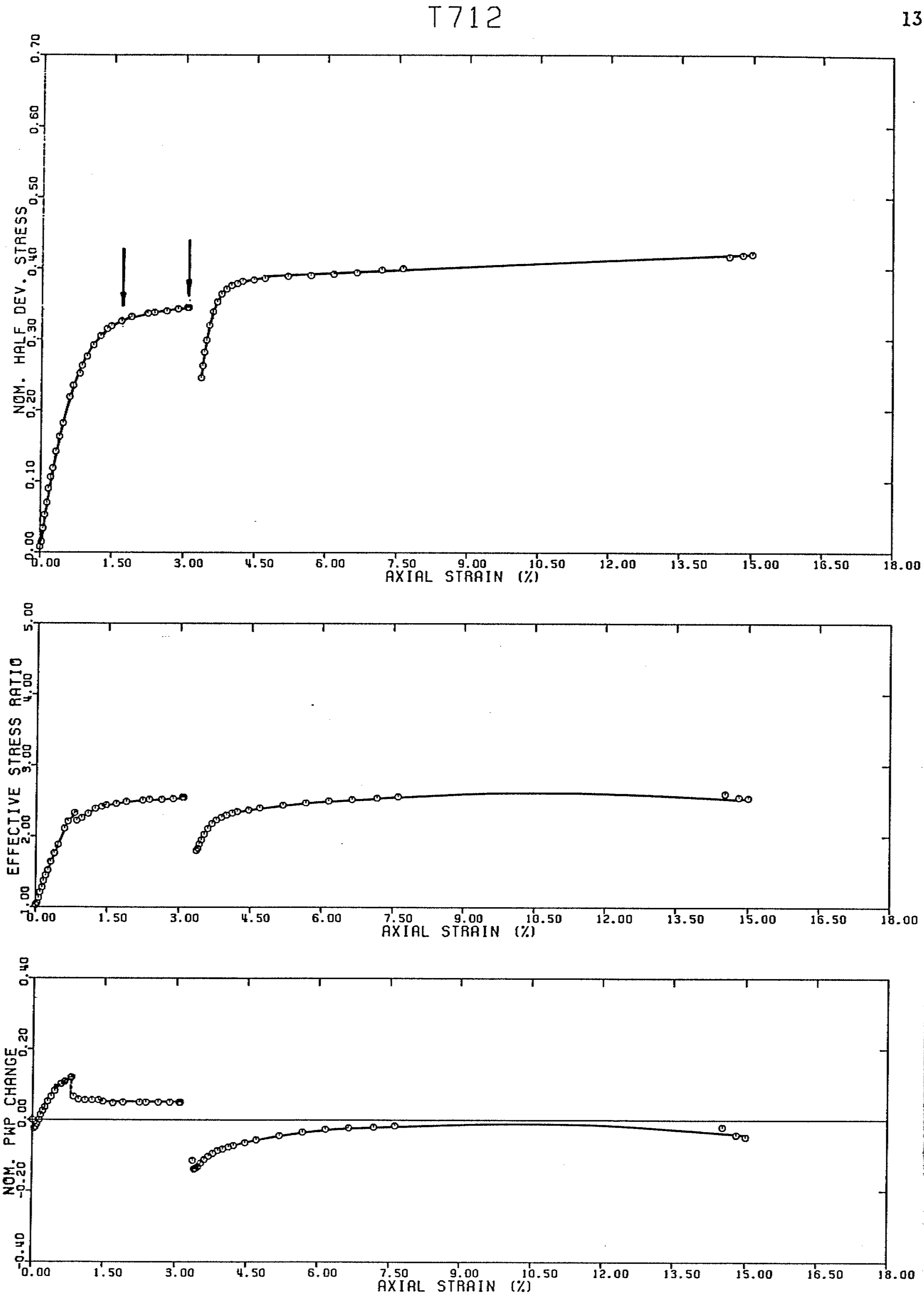


FIGURE 6.6 - UNDRAINED STRESS-STRAIN POREWATER PRESSURE RESULTS, T712

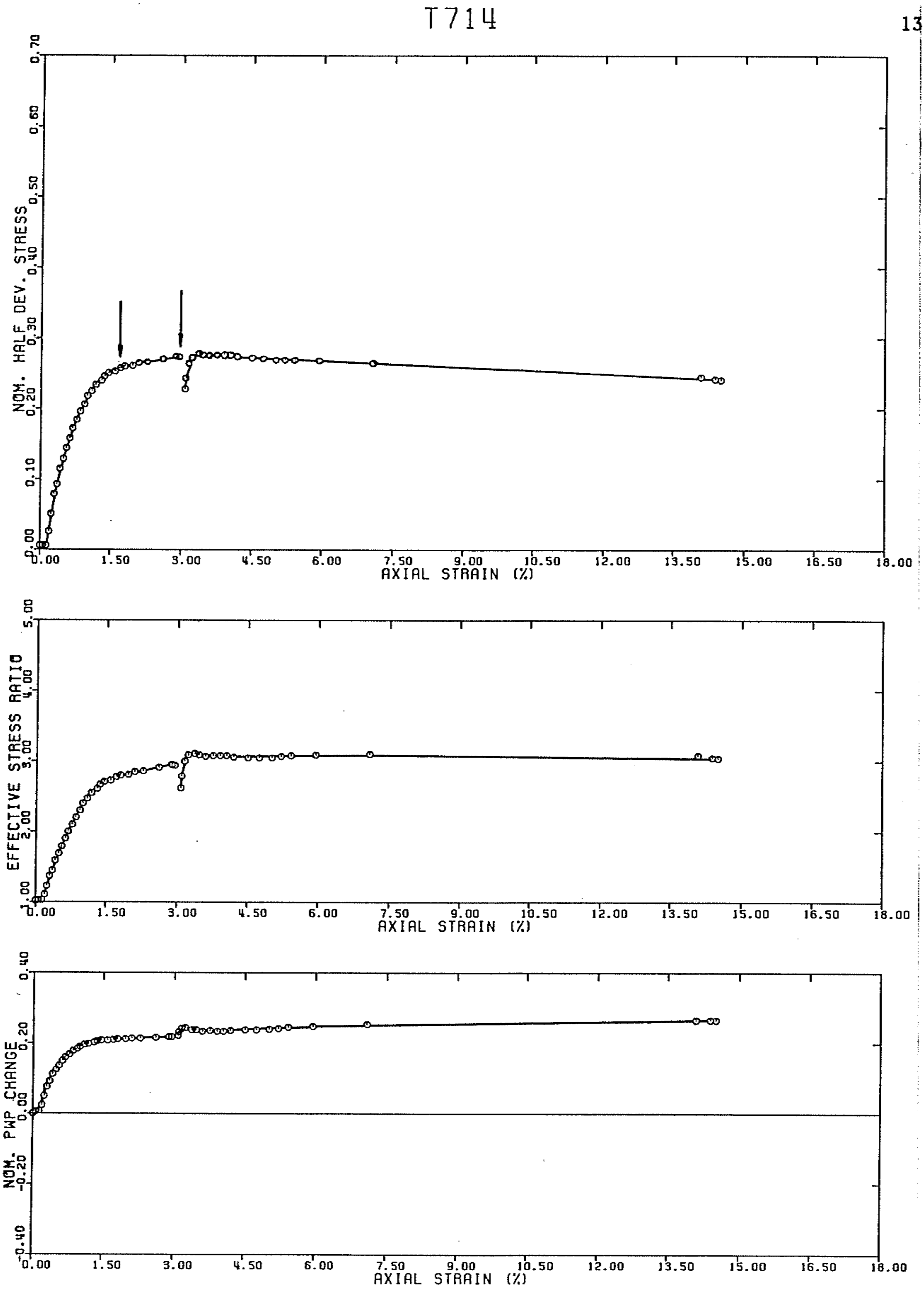


FIGURE 6.7 - UNDRAINED STRESS-STRAIN POREWATER PRESSURE RESULTS, T714

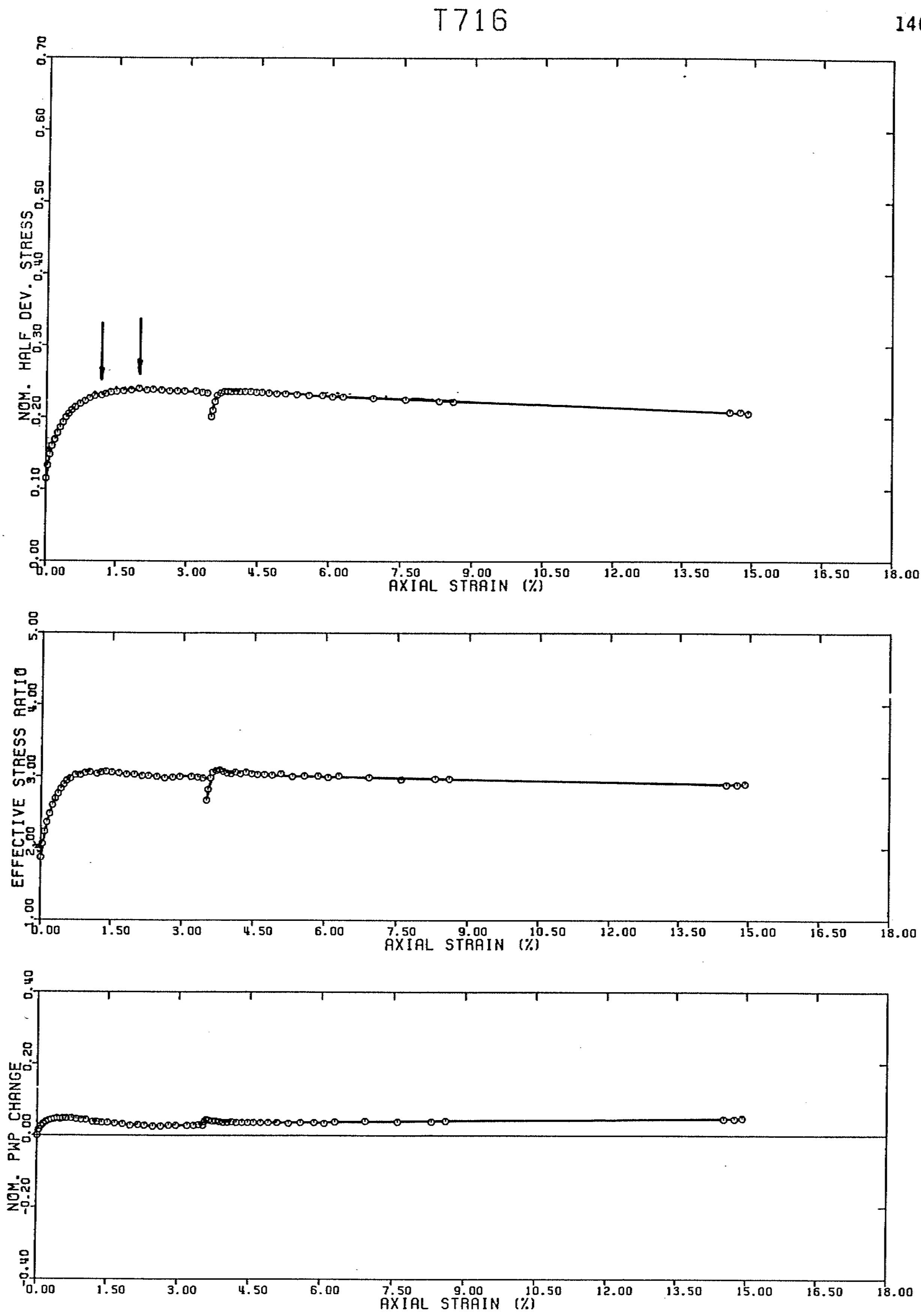


FIGURE 6.8 - UNDRAINED STRESS-STRAIN POREWATER PRESSURE RESULTS, T716

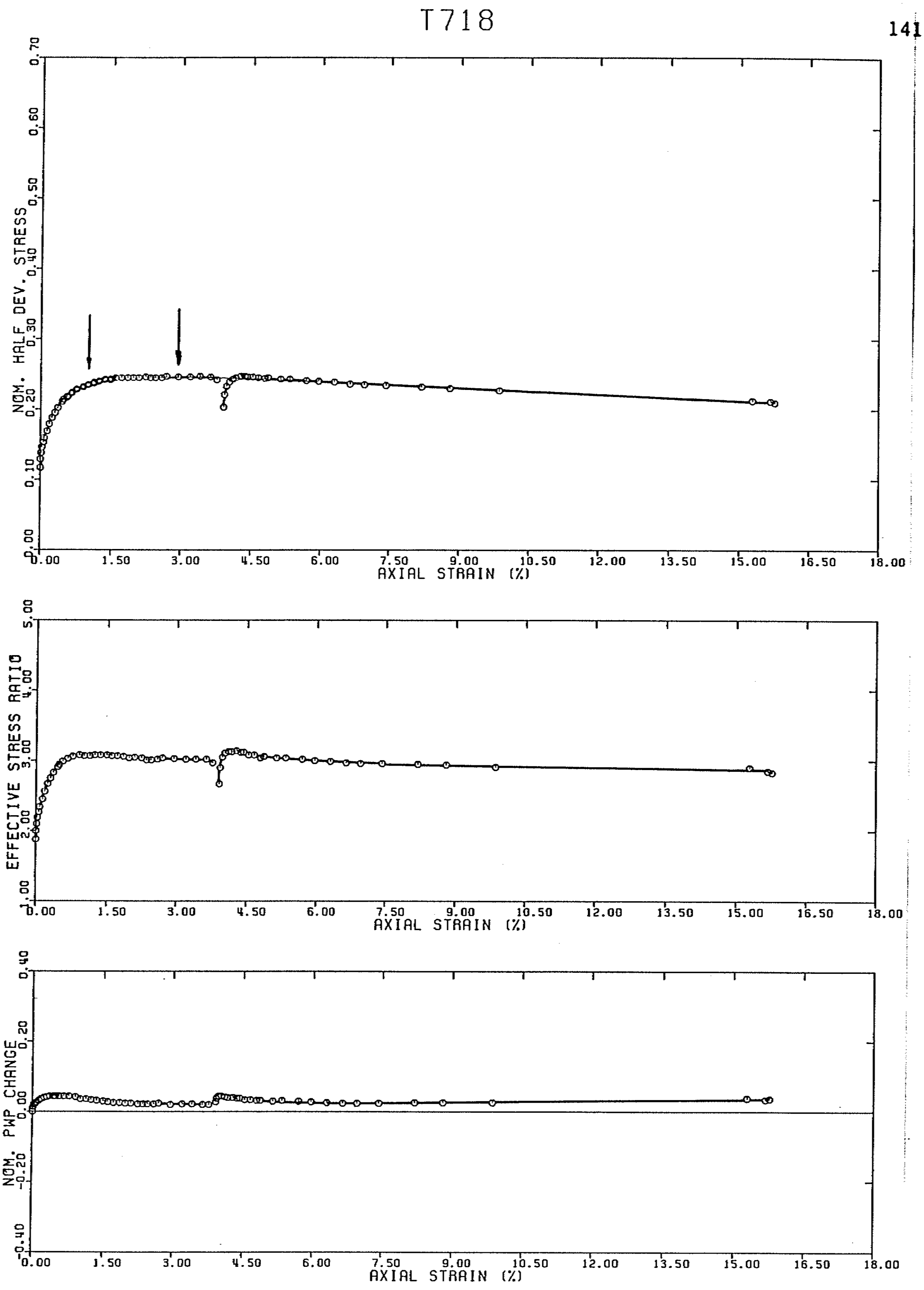


FIGURE 6.9 - UNDRAINED STRESS-STRAIN POREWATER PRESSURE RESULTS, T718

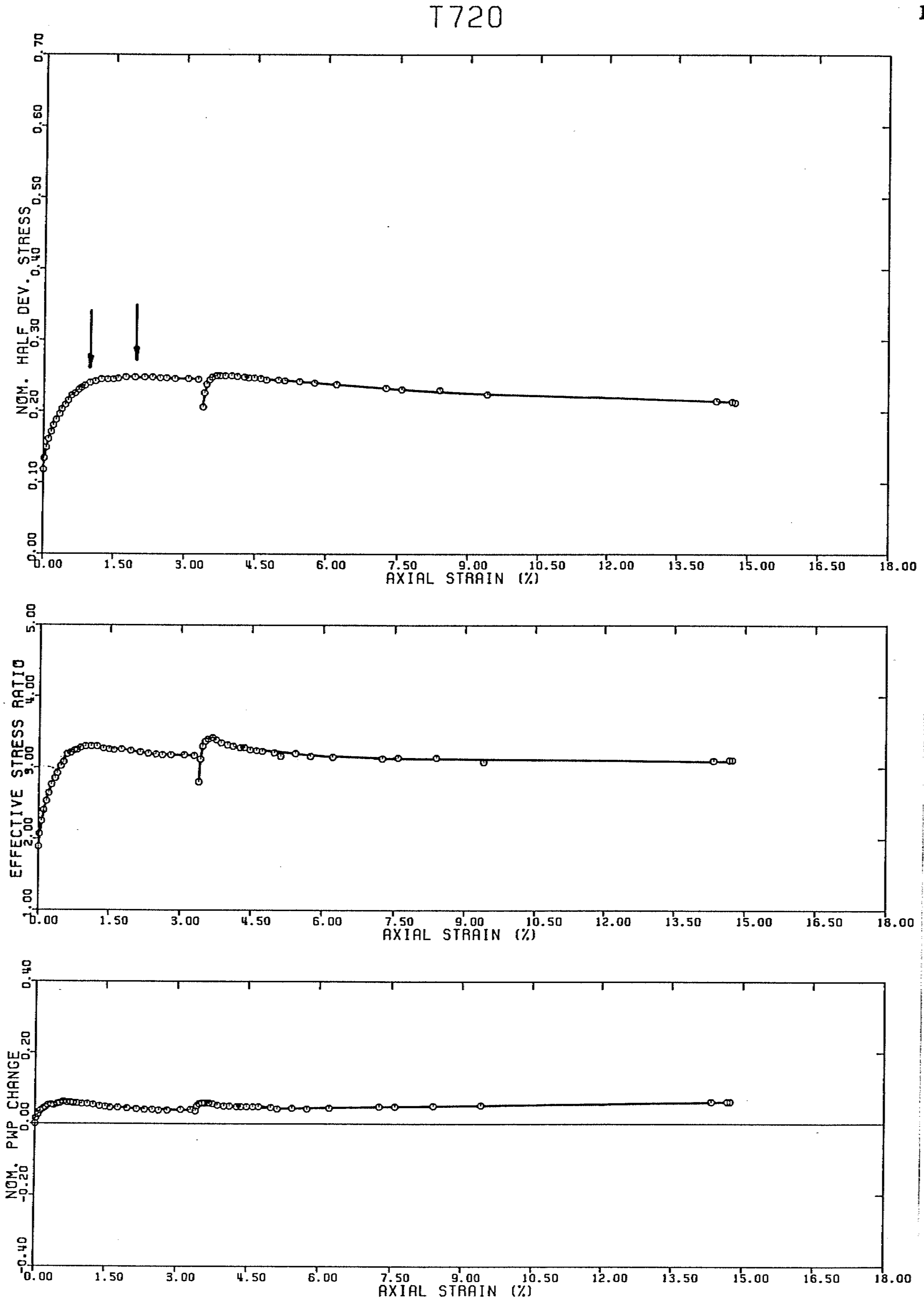
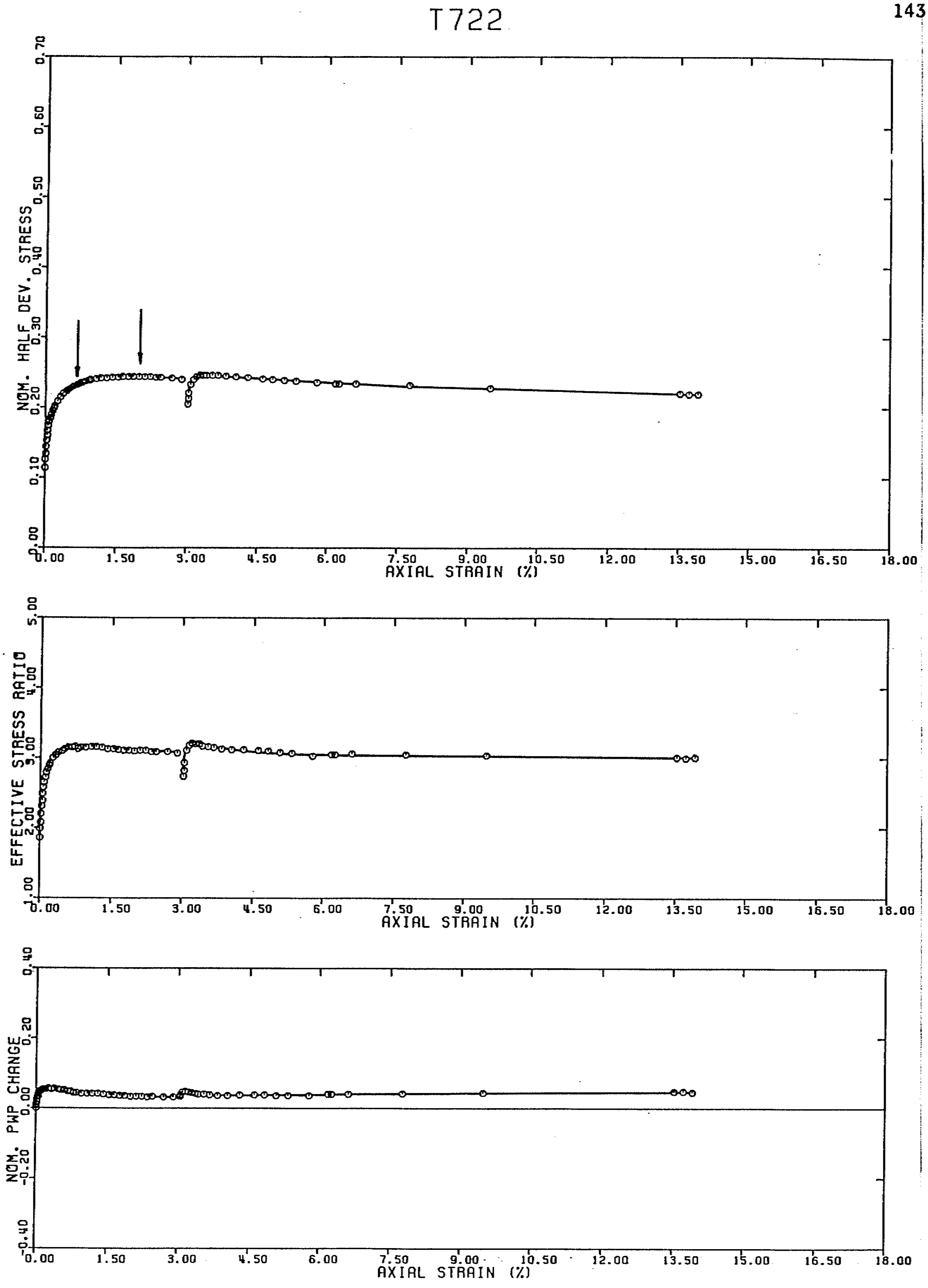


FIGURE 6.10 - UNDRAINED STRESS-STRAIN POREWATER PRESSURE RESULTS, T720



T722

FIGURE 6.11 - UNDRAINED STRESS-STRAIN POREWATER PRESSURE RESULTS, T722

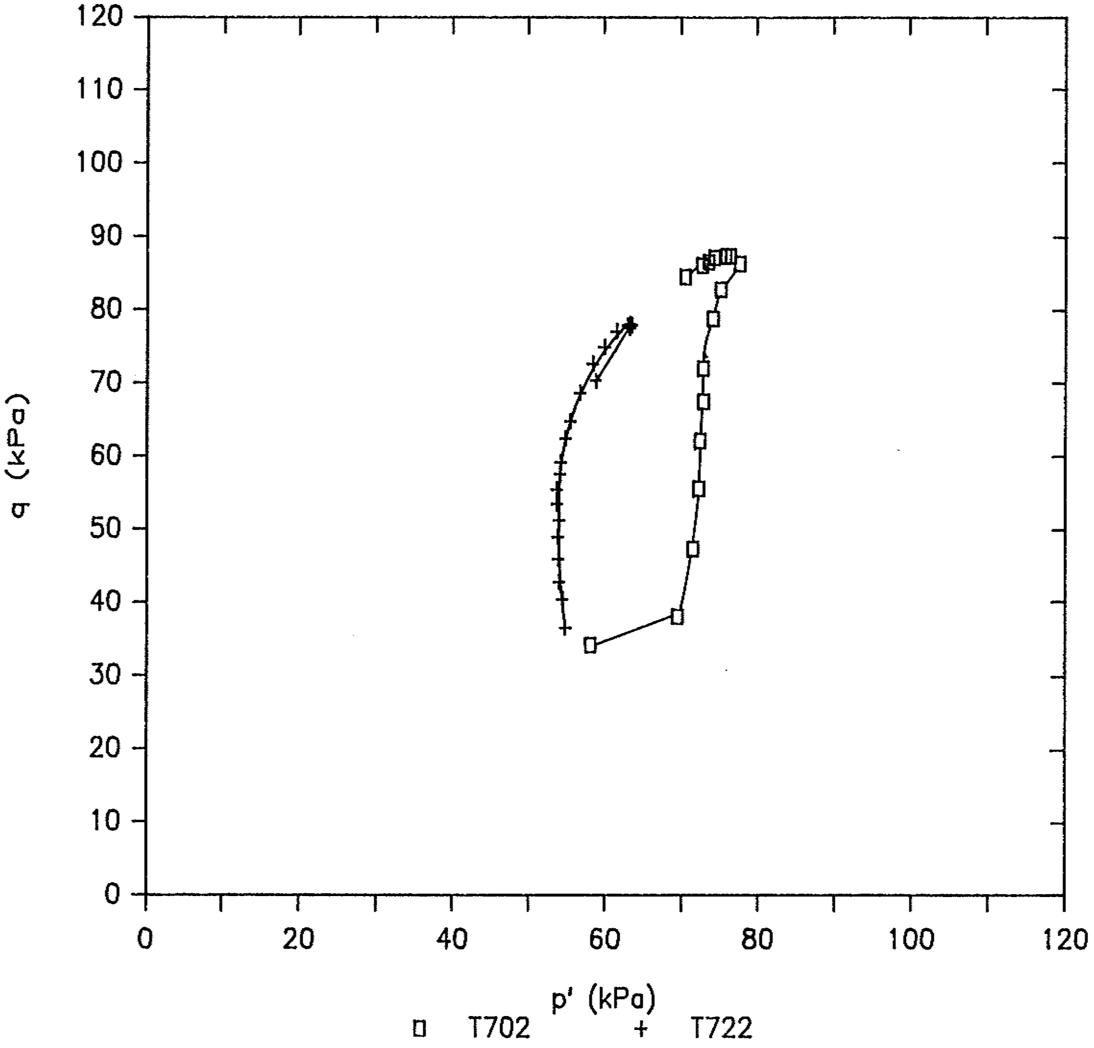


FIGURE 6.12 - EFFECTIVE STRESS PATHS, T702, T722

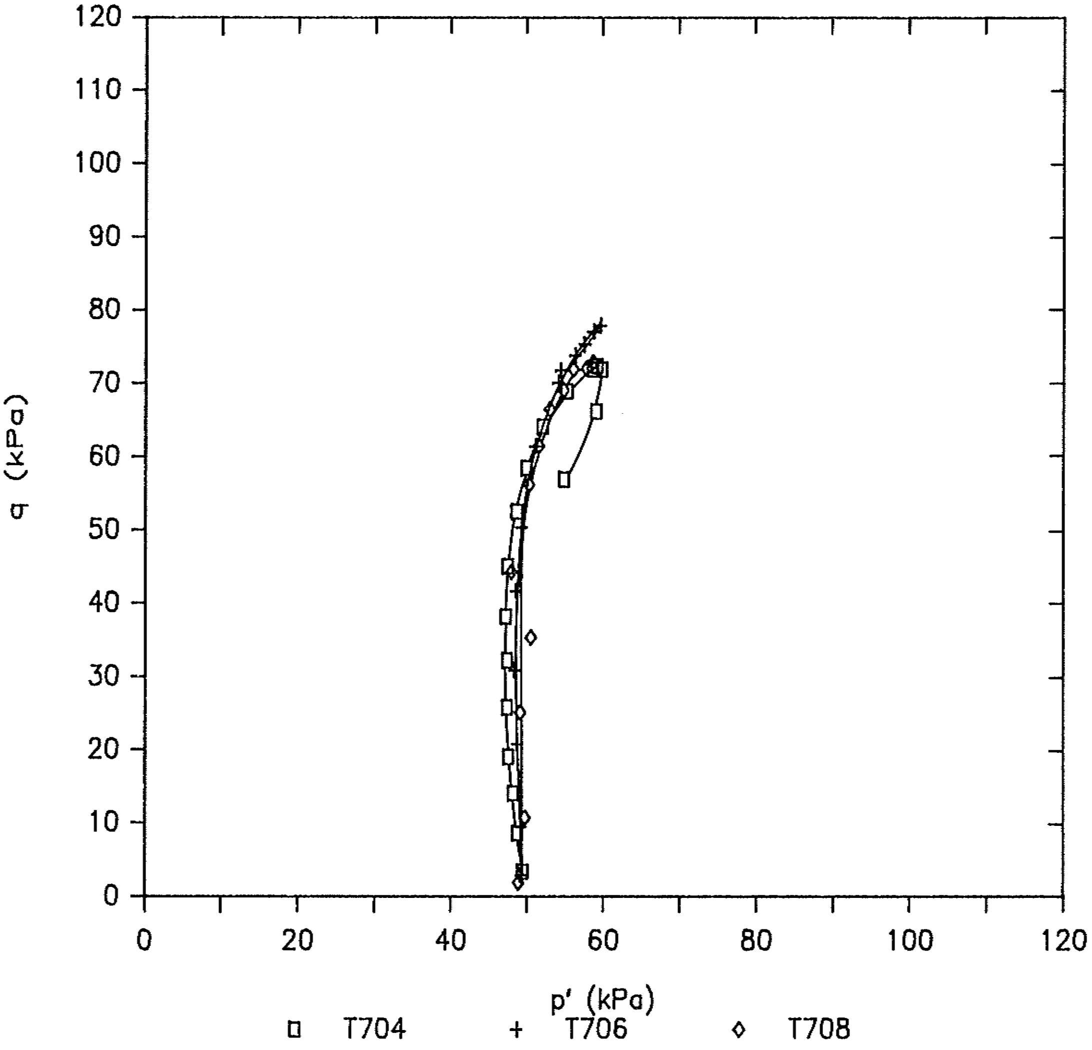


FIGURE 6.13 - EFFECTIVE STRESS PATHS, T704, T706, T708

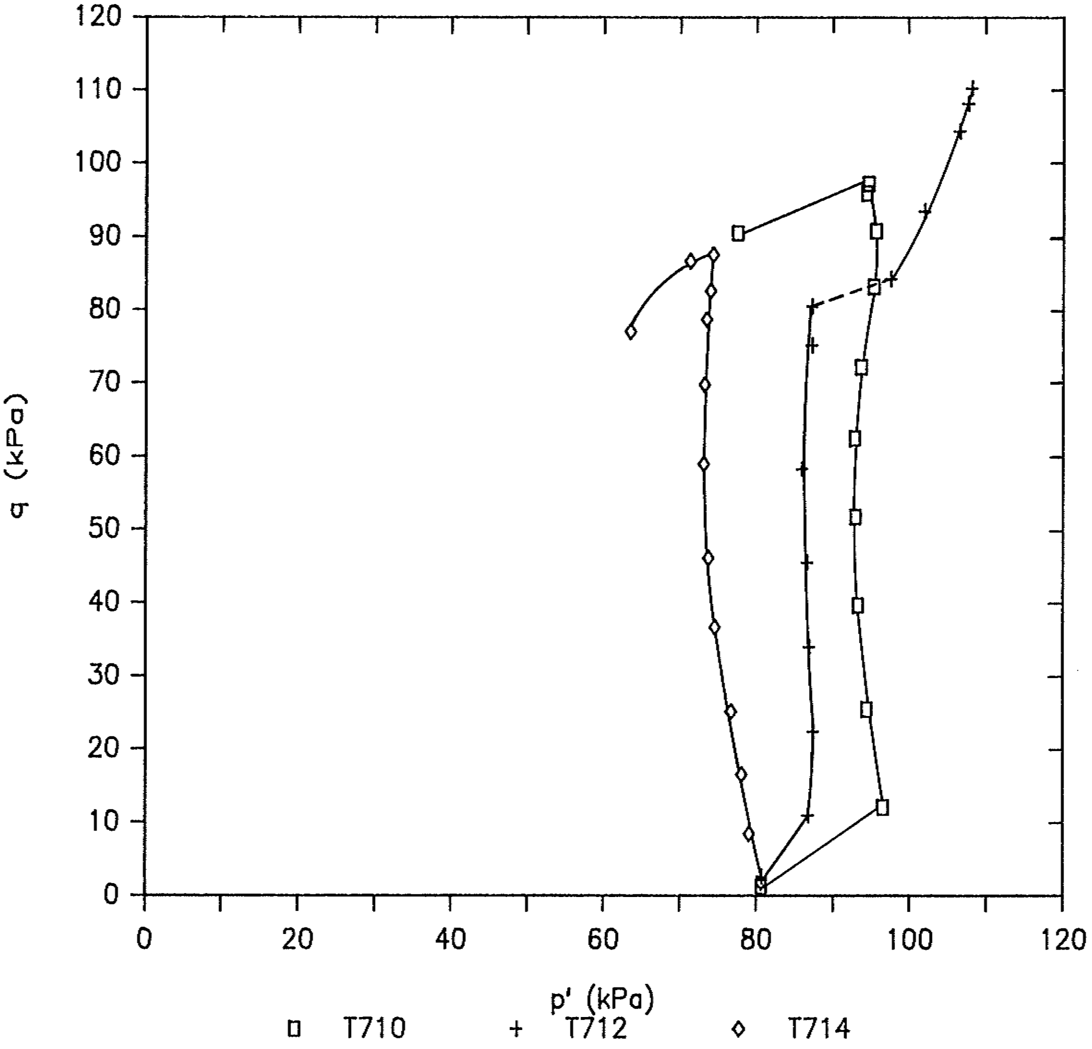


FIGURE 6.14 - EFFECTIVE STRESS PATHS, T710, T712, T714

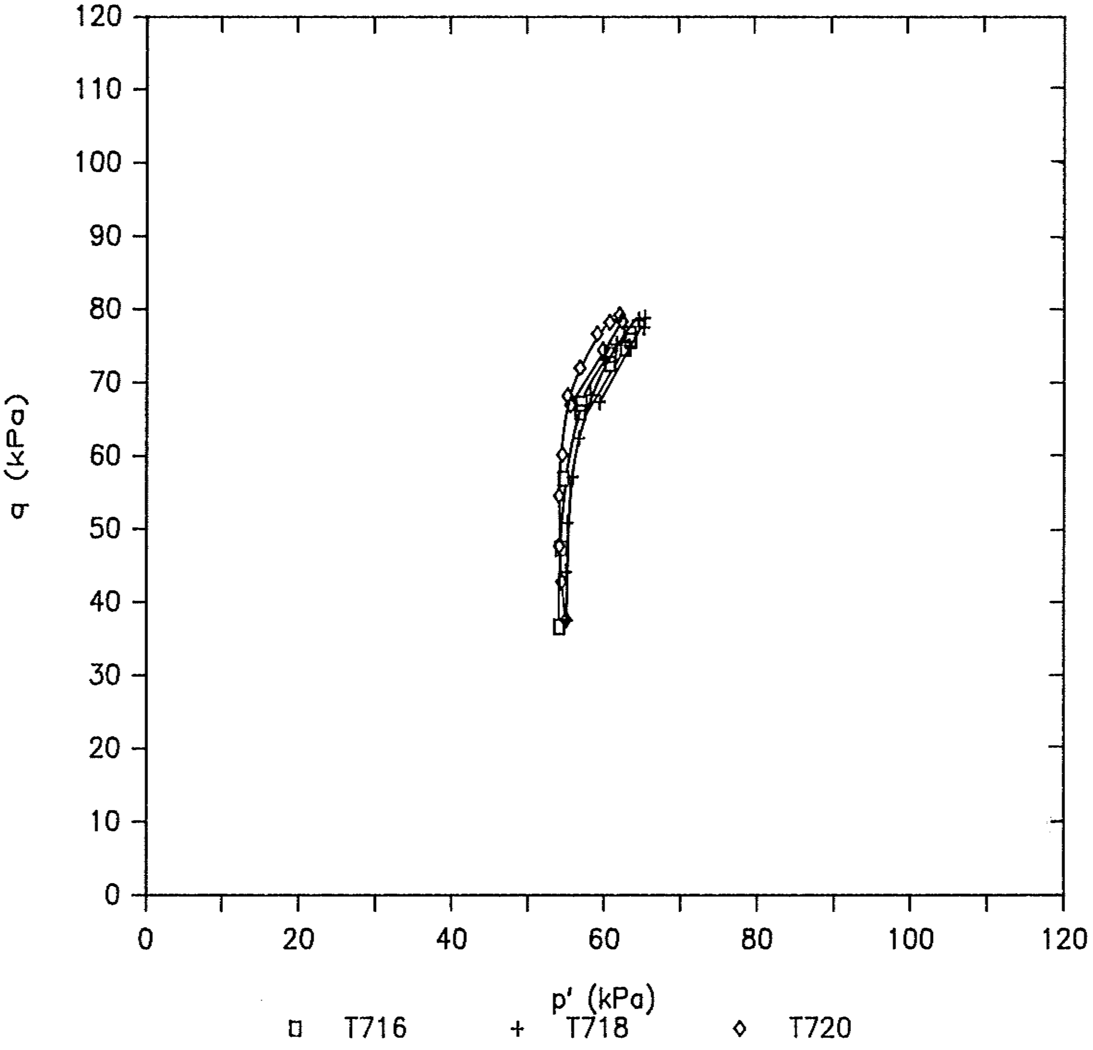


FIGURE 6.15 - EFFECTIVE STRESS PATHS, T716, T718, T720

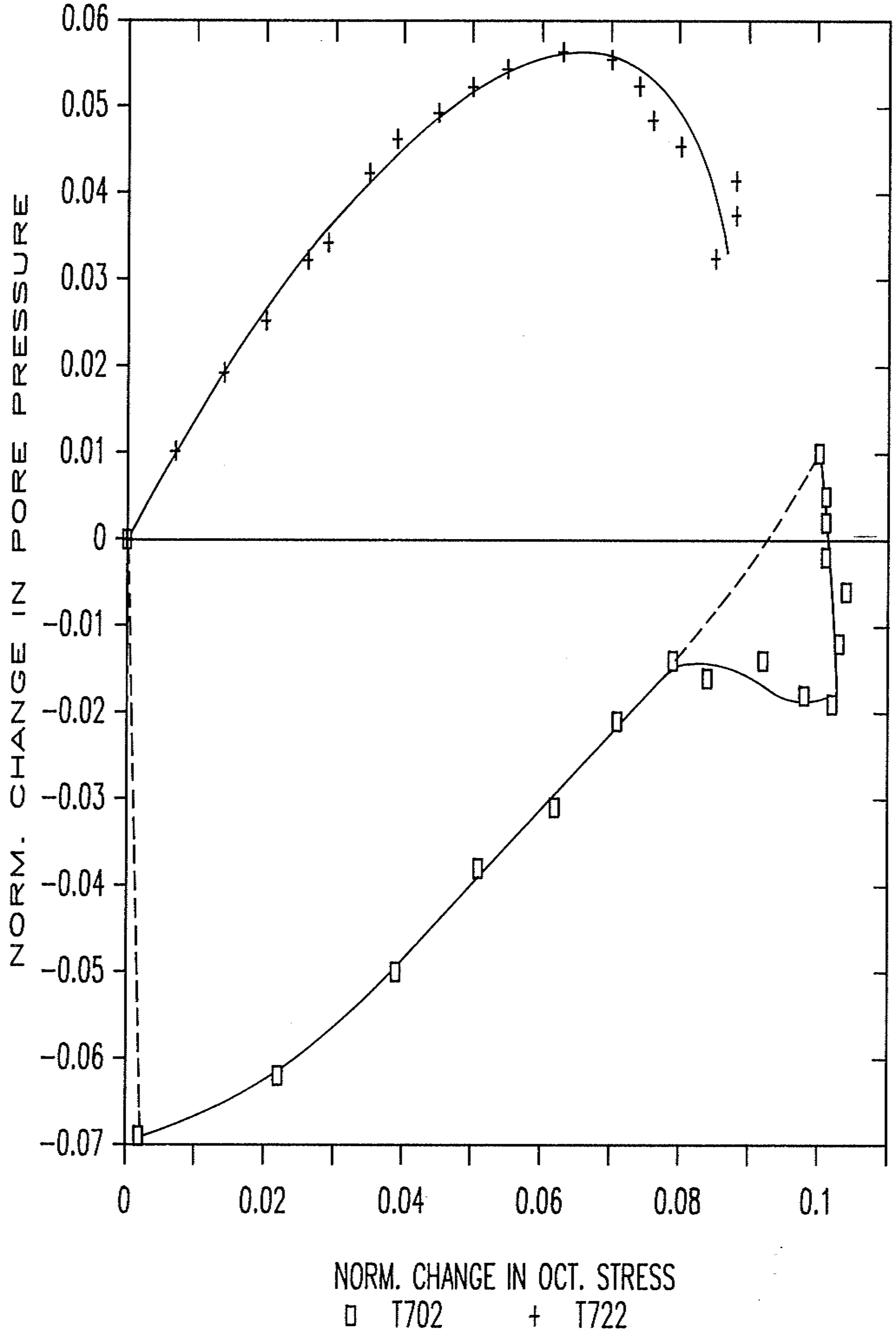


FIGURE 6.16 - POREWATER PRESSURE BEHAVIOUR, $\Delta u/\sigma'_{vc}$ vs $\Delta p/\sigma'_{vc}$; T702, T722

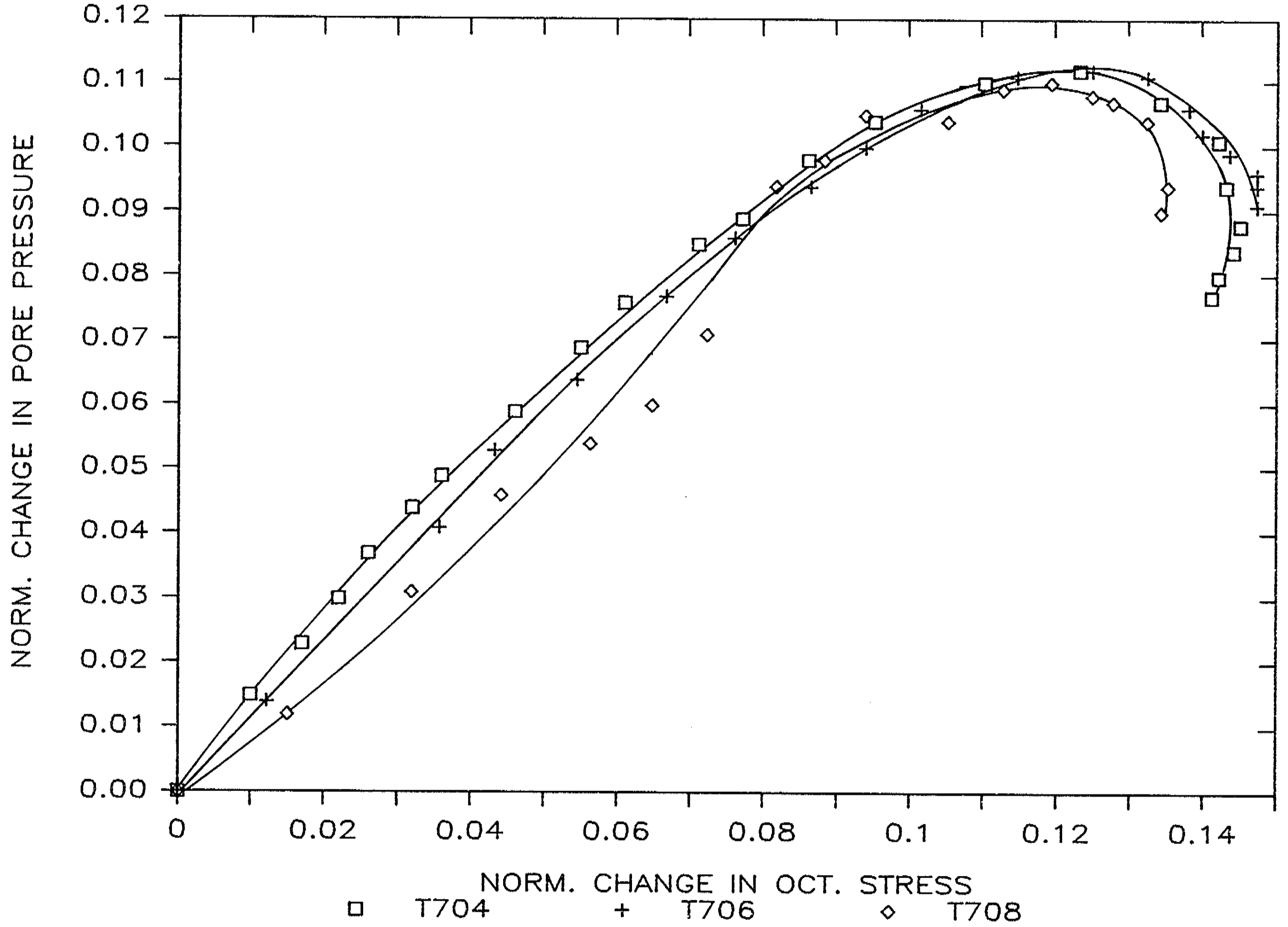


FIGURE 6.17 - POREWATER PRESSURE BEHAVIOUR, $\Delta u/\sigma'_{vc}$ vs $\Delta p/\sigma'_{vc}$; T704, T706, T708

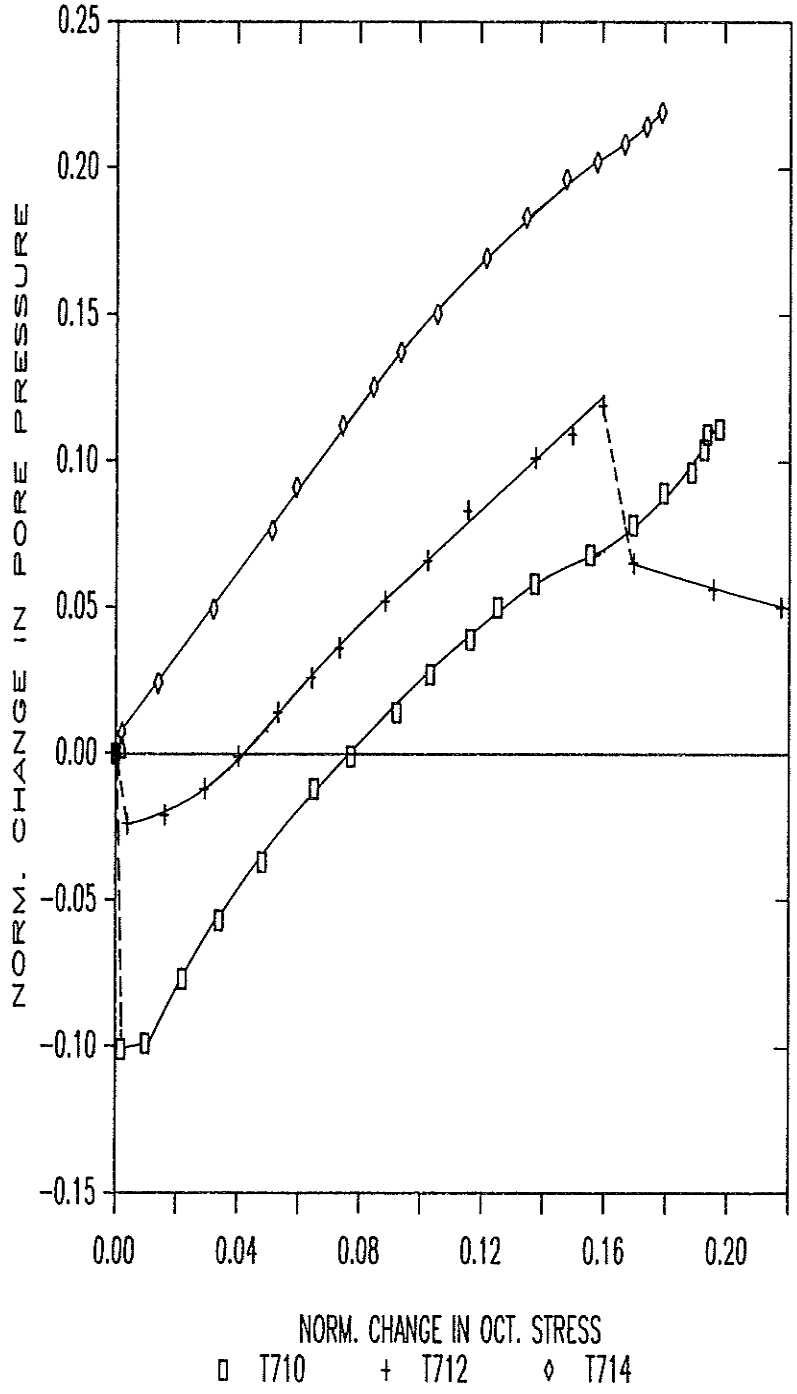


FIGURE 6.18 - POREWATER PRESSURE BEHAVIOUR, $\Delta u/\sigma'_{vc}$ vs $\Delta p/\sigma'_{vc}$; T710, T712, T714

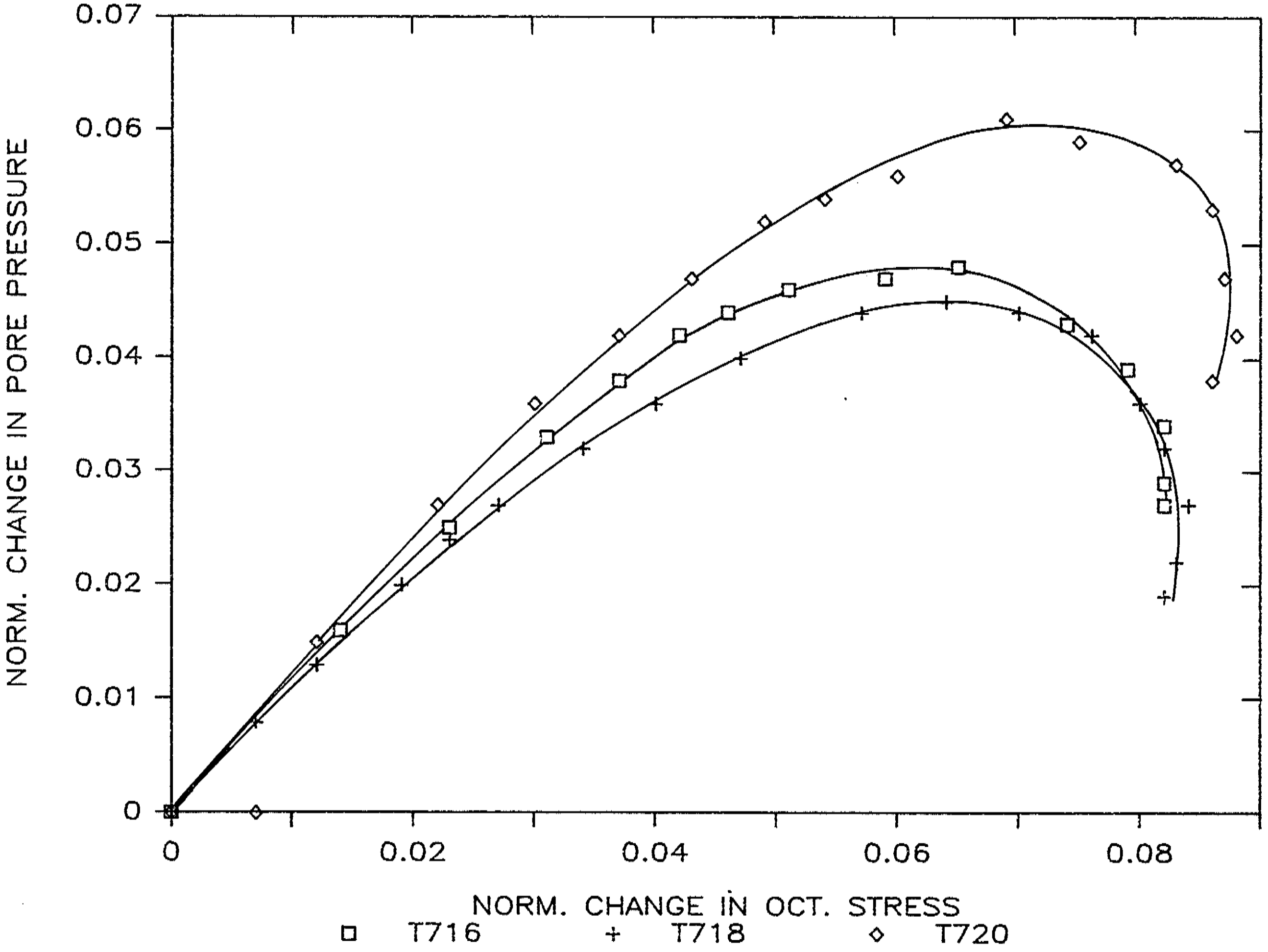


FIGURE 6.19 - POREWATER PRESSURE BEHAVIOUR, $\Delta u/\sigma'_{vc}$ vs $\Delta p/\sigma'_{vc}$; T716, T718, T720

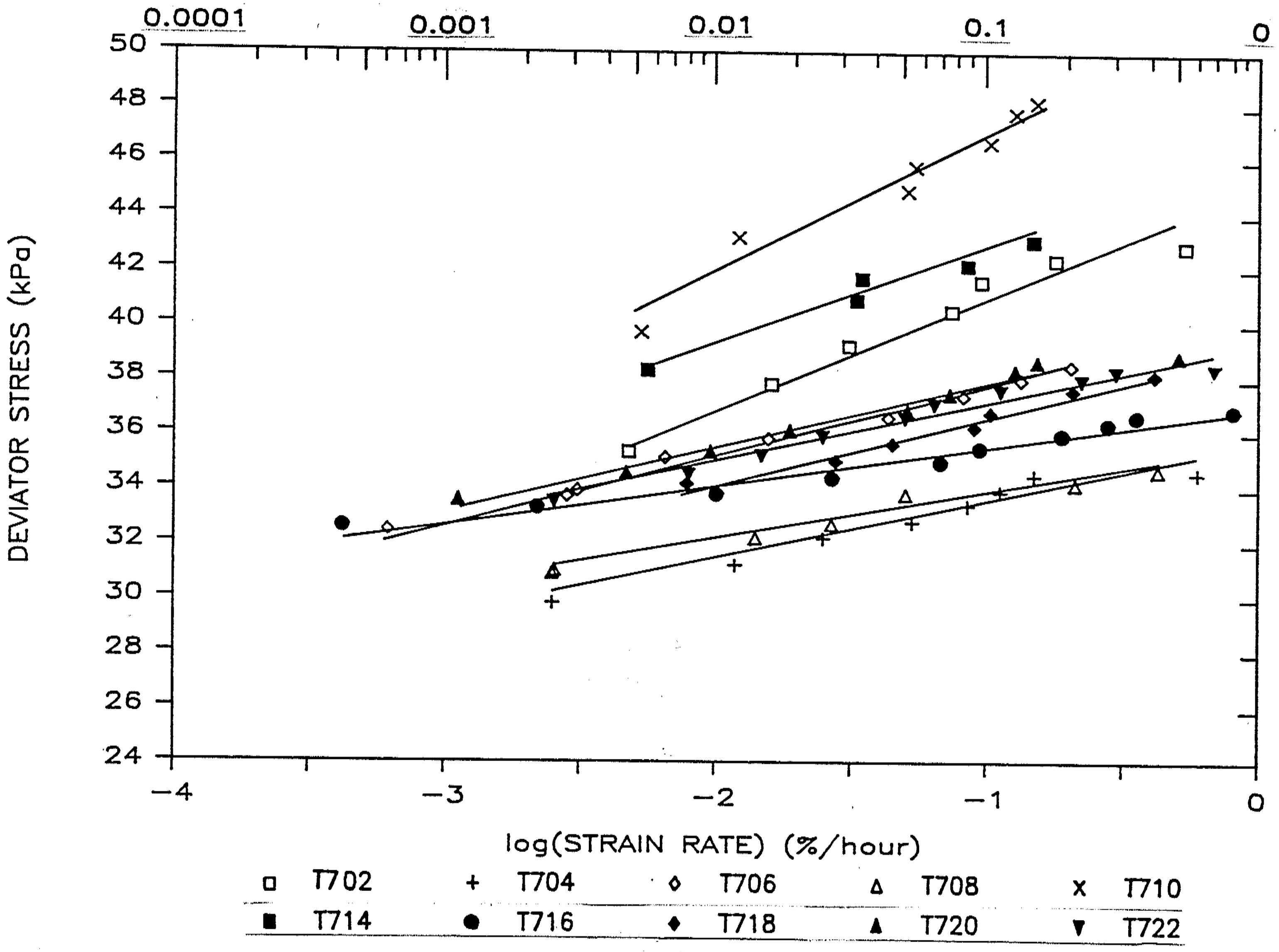


FIGURE 6.20 - STRAIN RATE EFFECTS FROM RELAXATION TESTS

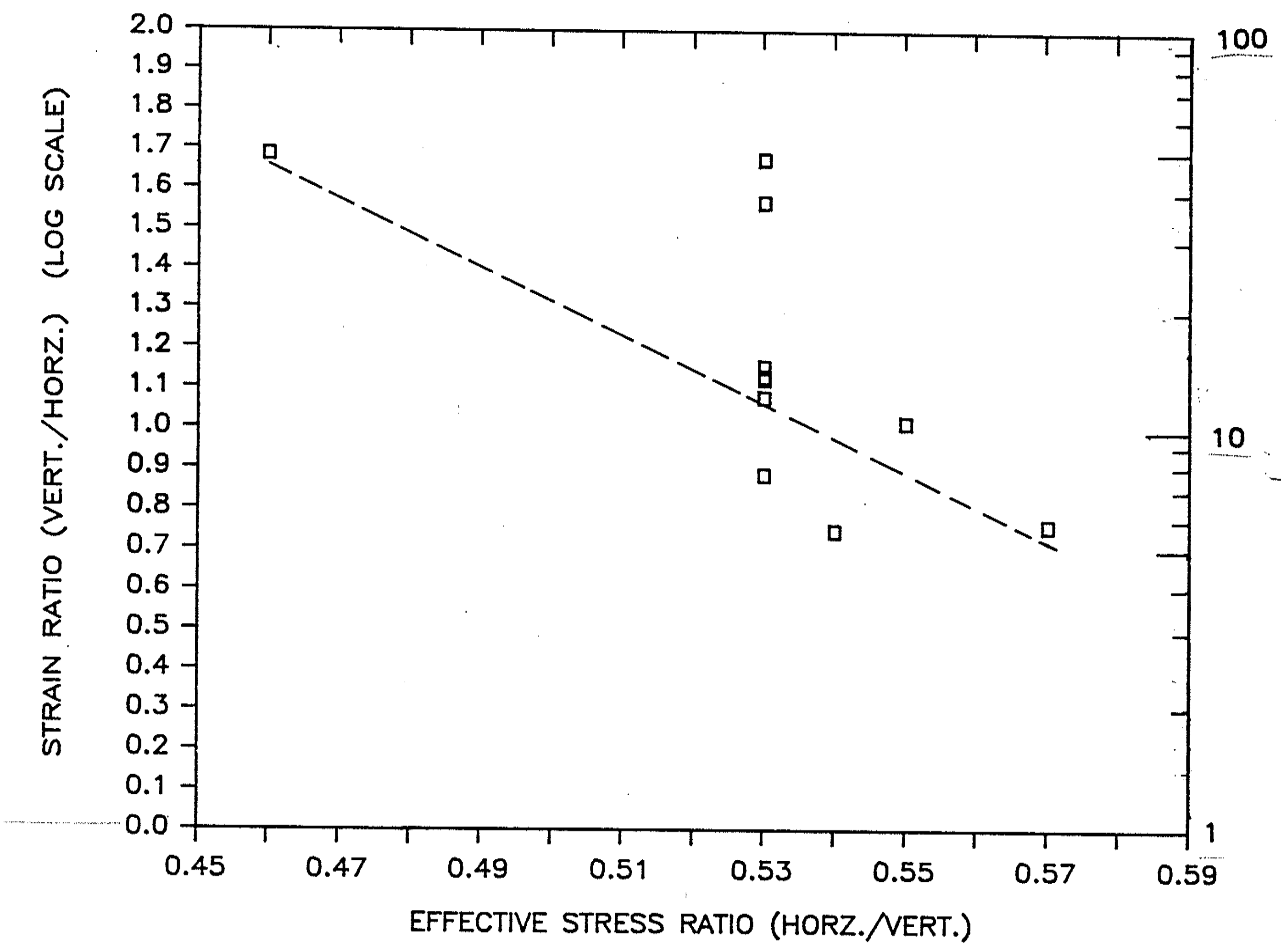


FIGURE 7.1 - LOG(STRAIN RATIO $= \varepsilon_{1c} / \varepsilon_{3c}$) vs (STRESS RATIO $= \sigma'_3 / \sigma'_1$)

AT THE END OF TRIAXIAL CONSOLIDATION

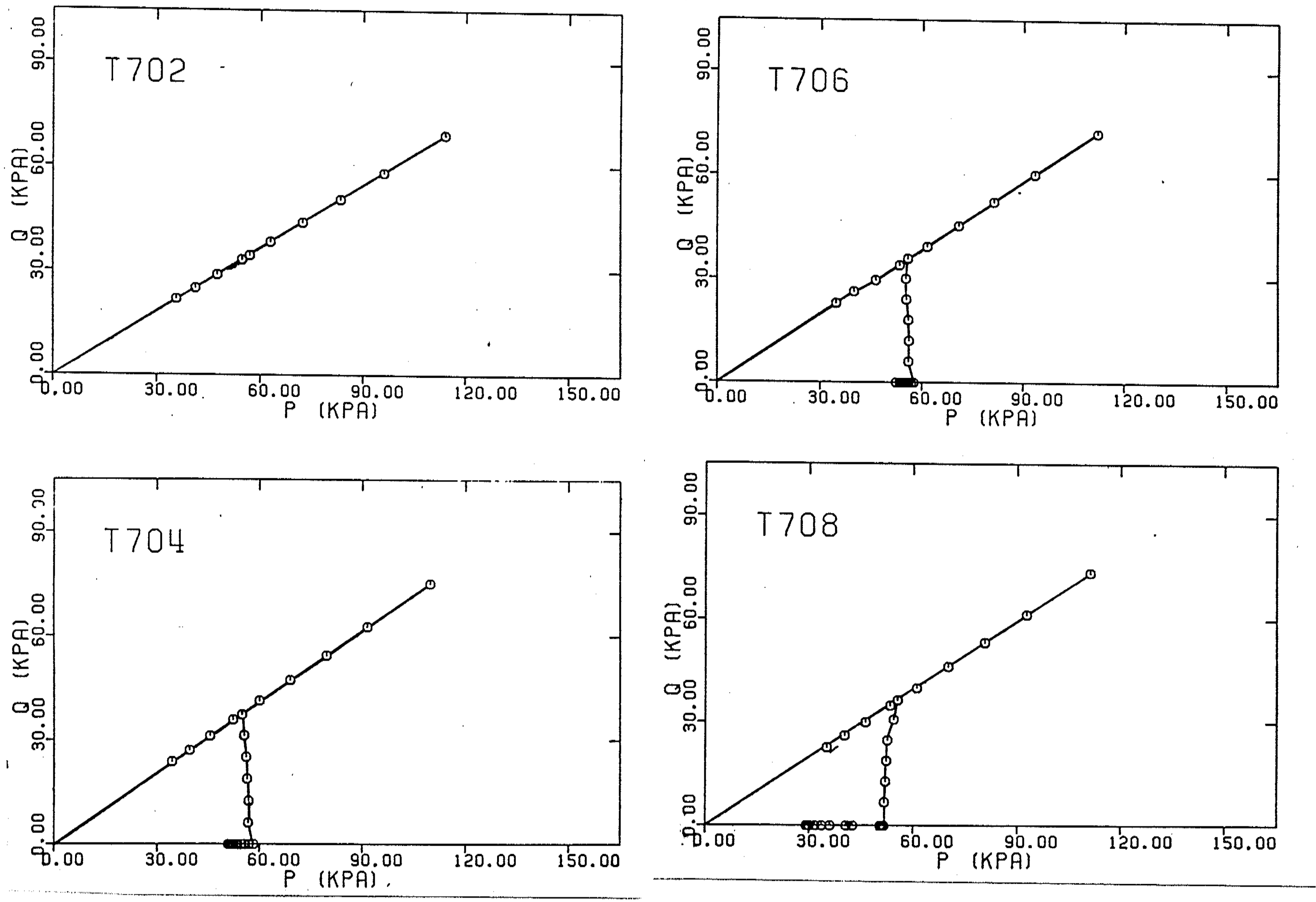


FIGURE 7.2a - STRESS PATHS FOR TRIAXIAL CONSOLIDATION, T702

FIGURE 7.2b,c,d - STRESS PATHS FOR TRIAXIAL CONSOLIDATION,
UNLOADING AND DWELL, T704, T706, T708

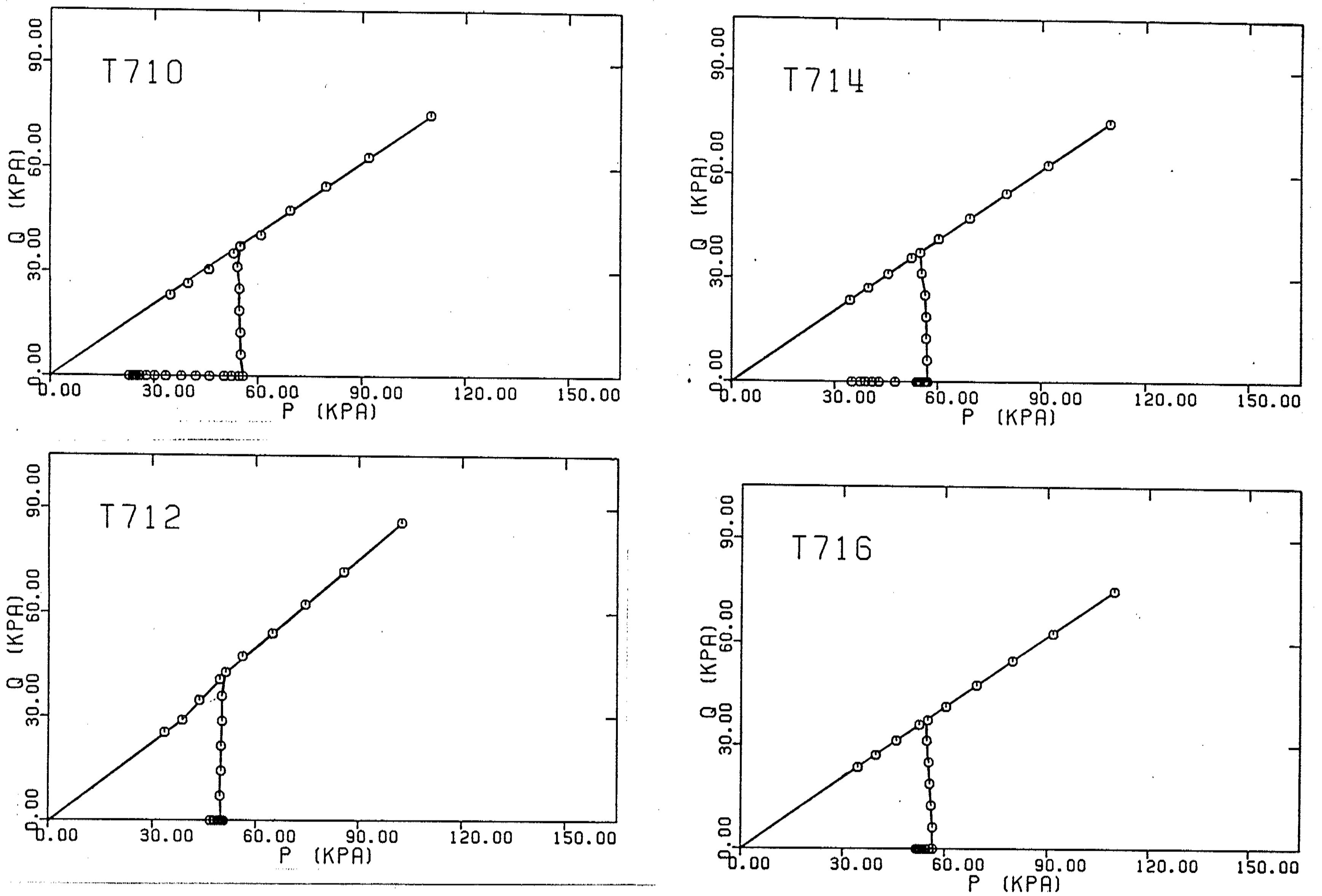
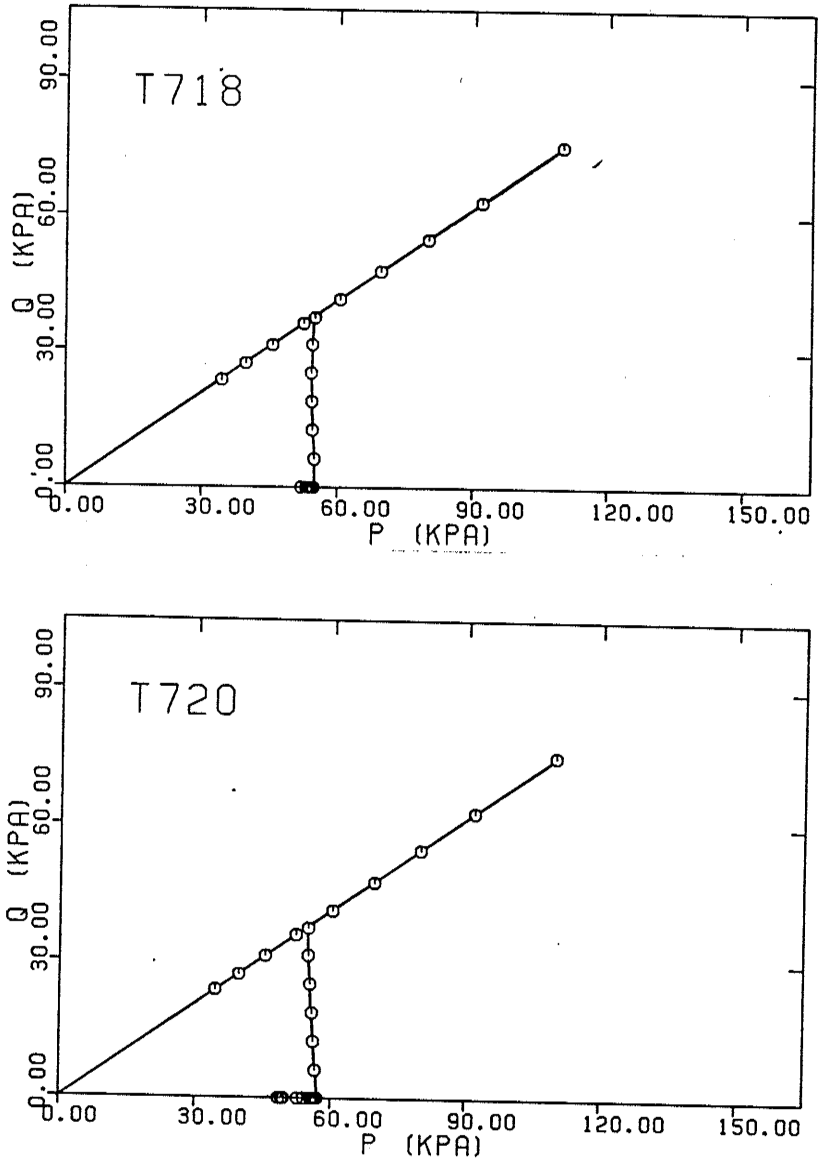


FIGURE 7.3a,b,c,d - STRESS PATHS FOR TRIAXIAL CONSOLIDATION, UNLOADING AND DWELL, T710, T712, T714, T716



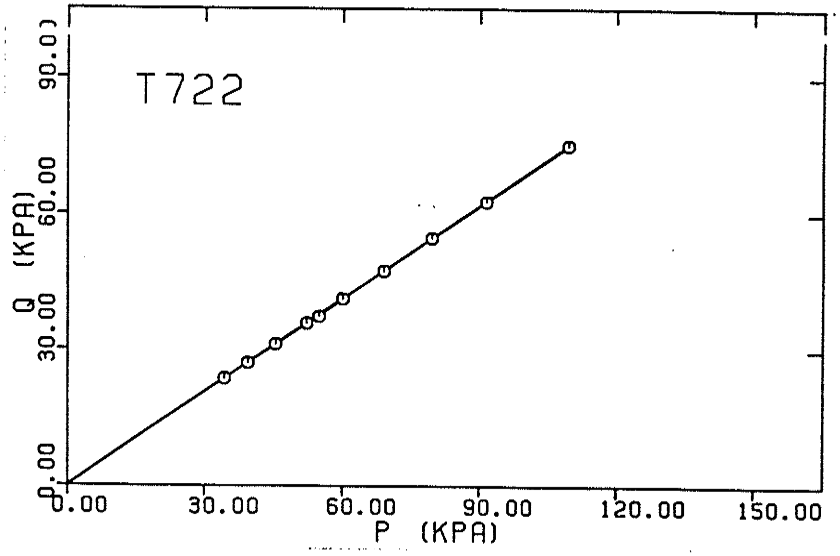


FIGURE 7.4a,b - STRESS PATHS FOR TRIAXIAL CONSOLIDATION, UNLOADING AND DWELL, T718, T720

FIGURE 7.4c - STRESS PATHS FOR TRIAXIAL CONSOLIDATION, T722

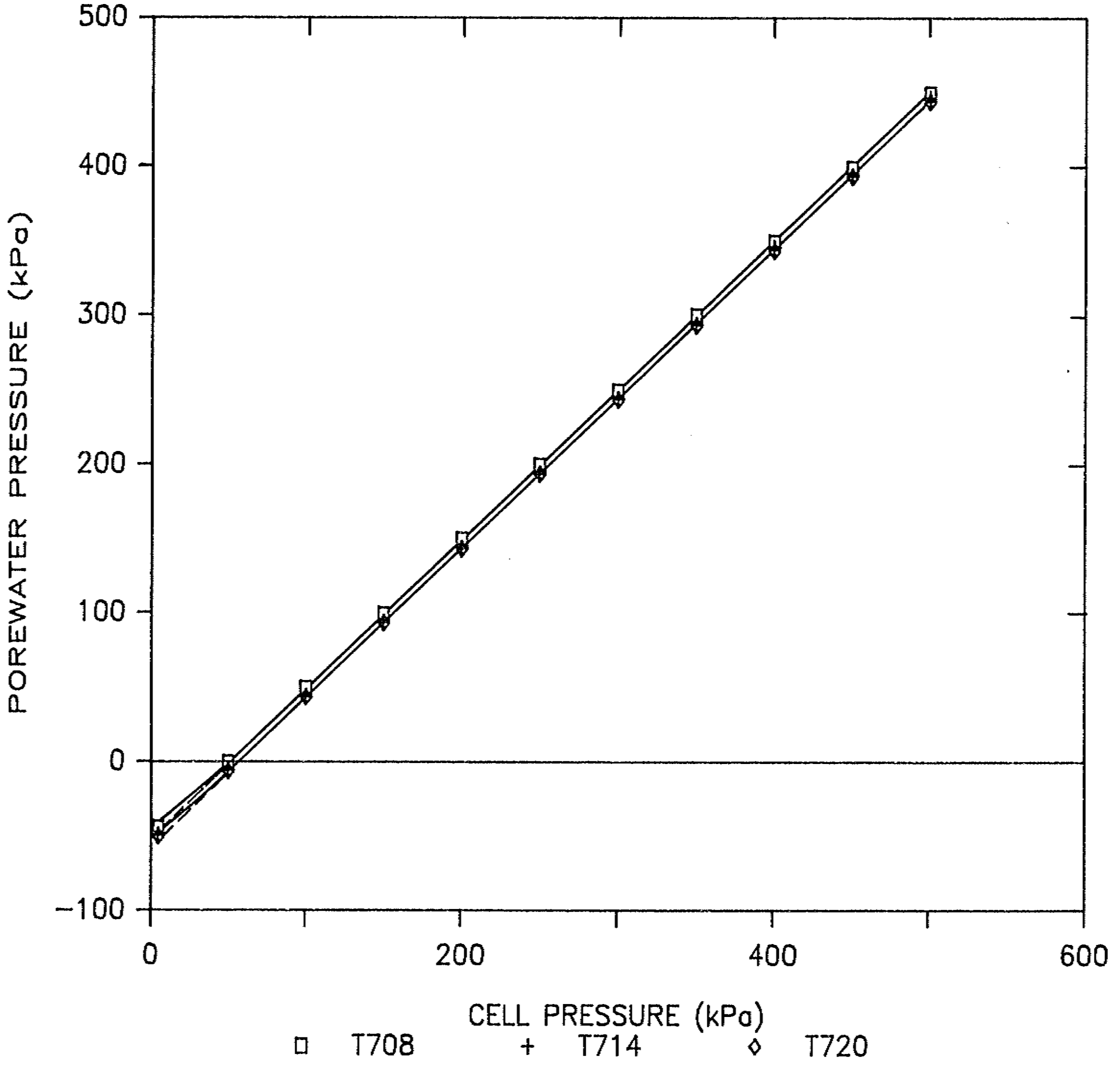
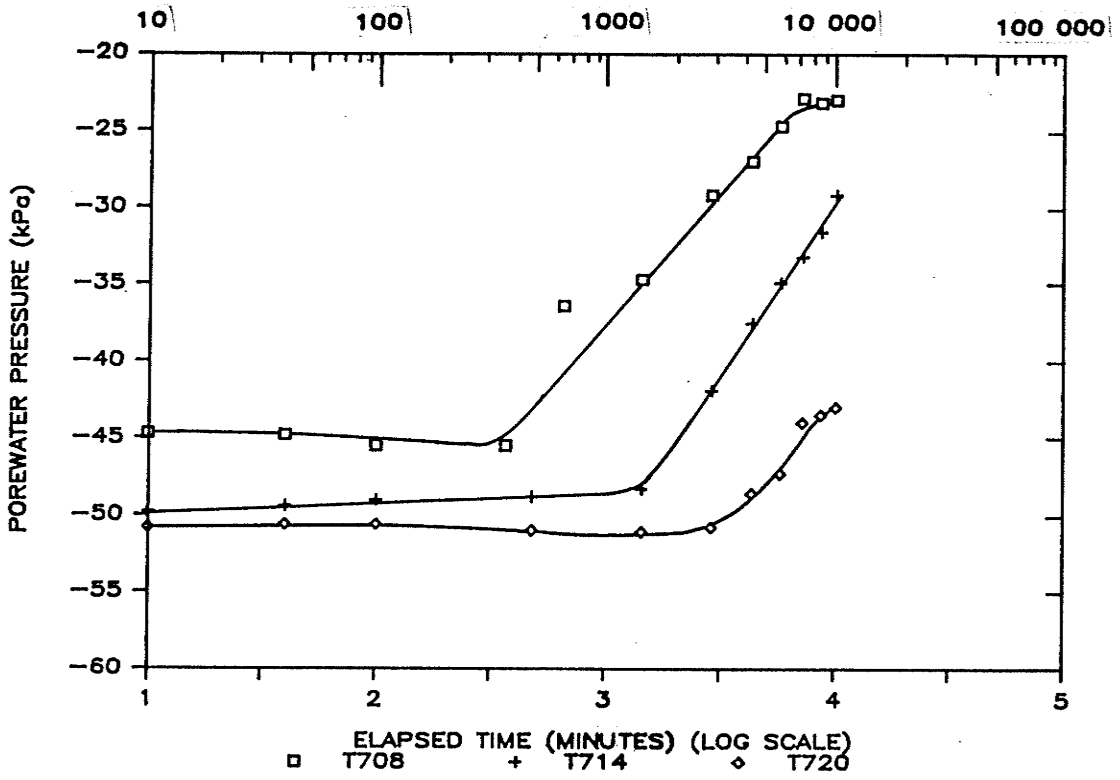
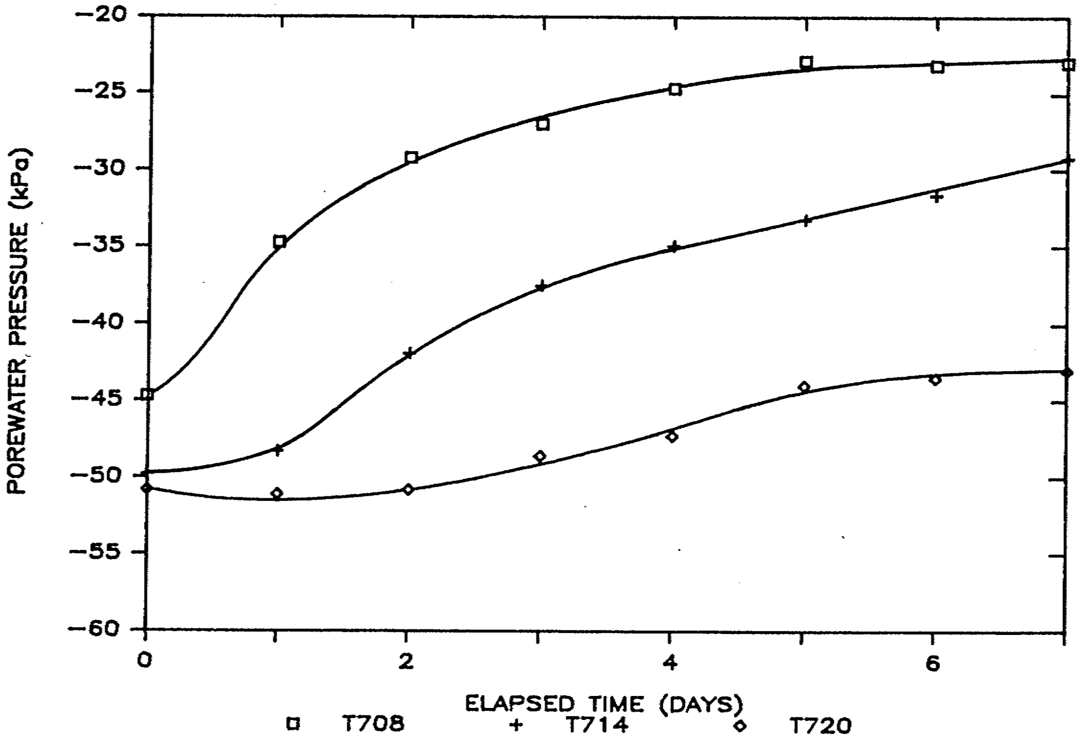


FIGURE 7.5 - POREWATER PRESSURE BEHAVIOUR DURING UNLOADING, T708, T714, T720



(a) POREWATER PRESSURE vs LOG(TIME IN MINUTES)



(b) POREWATER PRESSURE vs TIME IN DAYS

FIGURE 7.6a,b - POREWATER PRESSURE BEHAVIOUR DURING DWELLING, T708, T714, T720

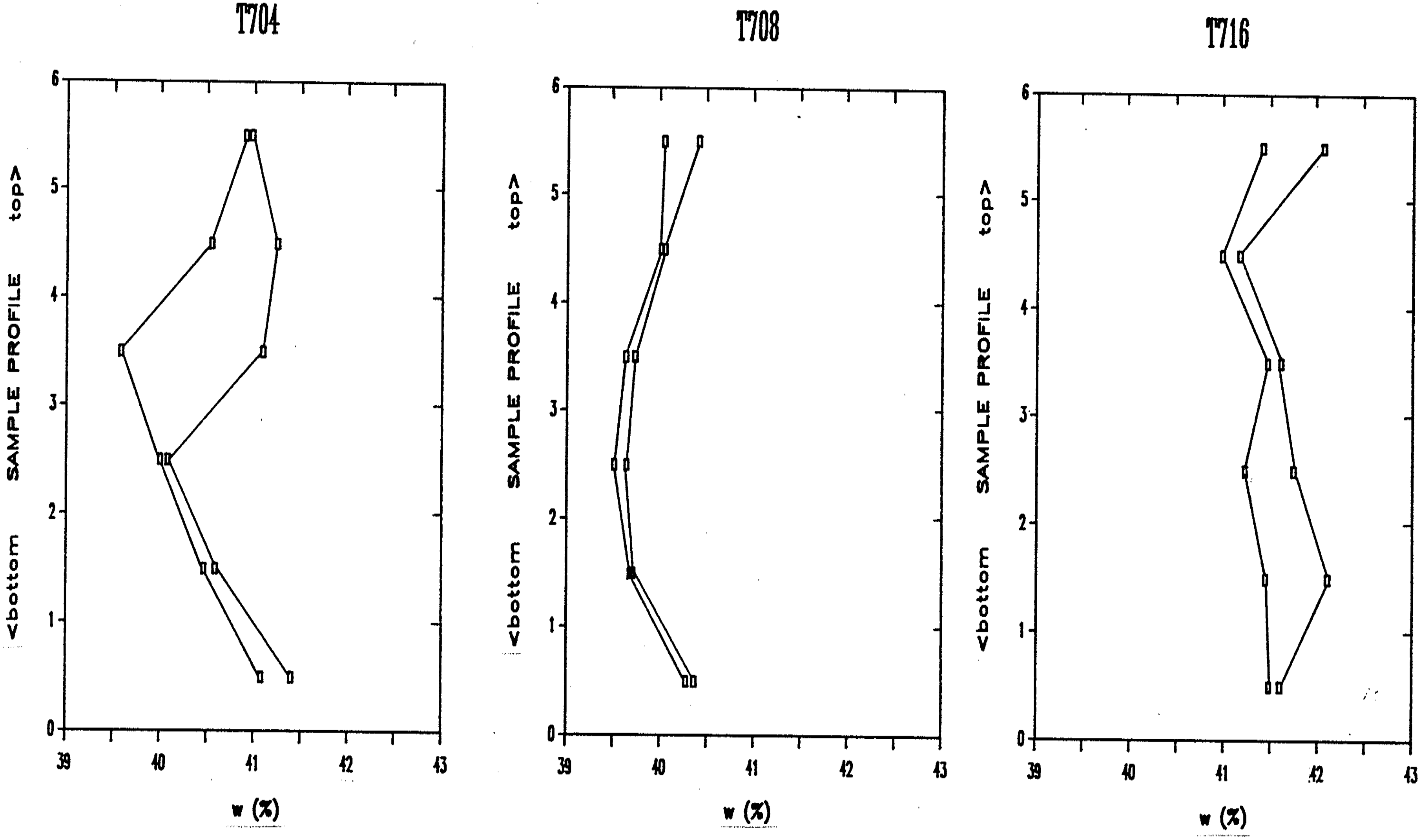


FIGURE 7.7 - MOISTURE CONTENT PROFILE ACROSS SAMPLES AFTER UNDRAINED SHEAR, T704, T708, T716

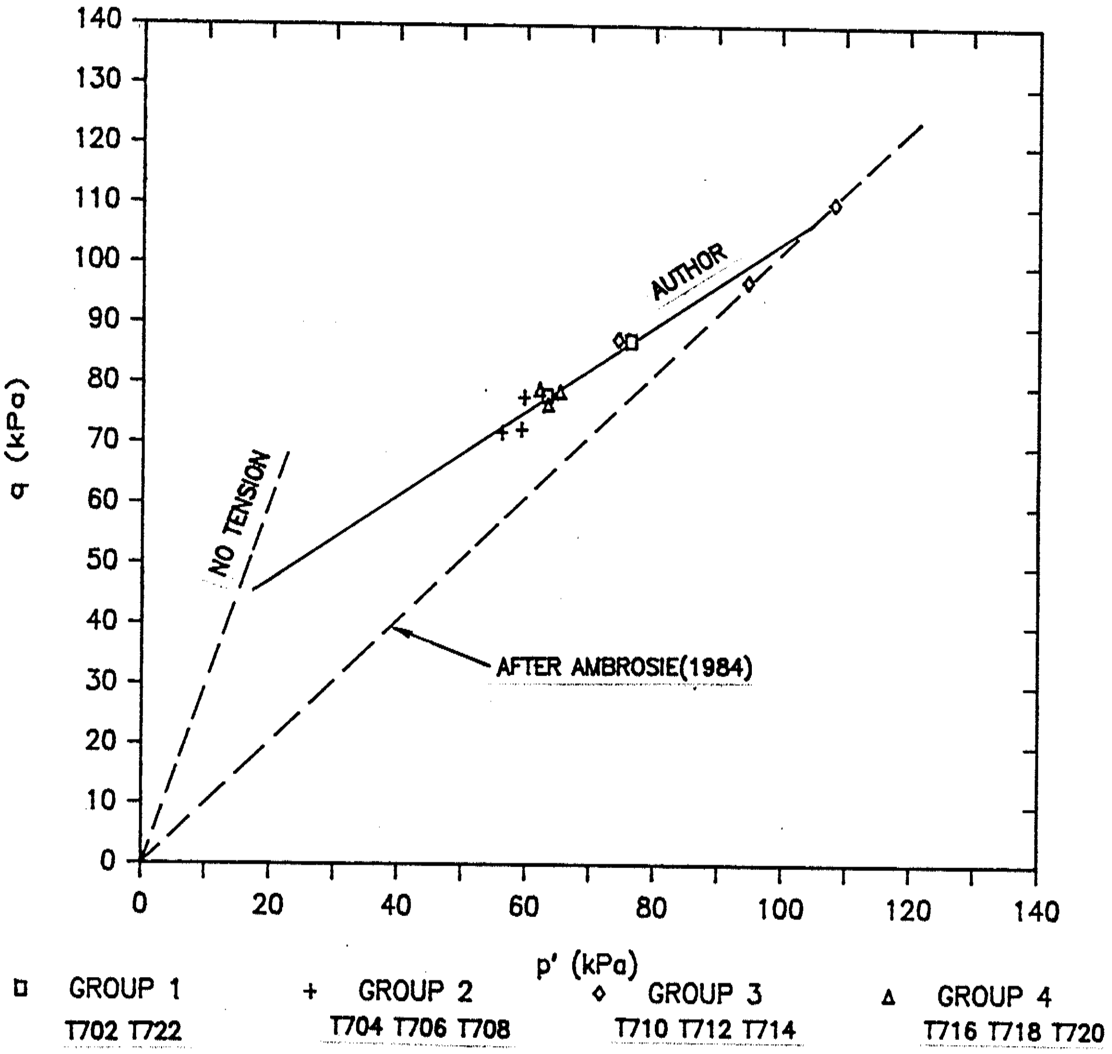


FIGURE 7.8 - NORMALLY AND OVERCONSOLIDATED RUPTURE ENVELOPE (σ'_{vc} = 160 kPa) OF ILLITE

APPENDIX A

SAMPLE EXTRUSION

Appendix A

SAMPLE EXTRUSION

A.1 INTRODUCTION

This note describes the steps used in employing the extrusion unit that was designed for extruding remoulded clay samples from consolidation cylinders in the Geotechnical Laboratories, University of Manitoba. The samples are then prepared for triaxial or oedometer tests using standard trimming and building-in procedures, which are described by Lew(1981).

The principle employed by this unit was suggested by Li(1983). The equipment (shown in Fig. 4.8) was designed by the author and his co-worker R. W. Ambrosie. Useful advice given by Dr. J. Graham during the design stage is much appreciated. Technical staff, Mr. J. Clark, Mr. S. Meyerhoff, and Mr. N. Piamsalee are acknowleged for their contribution in fabricating the equipment.

This note takes the form of a set of abbreviated instructions for employing the equipment.

A.2 EXTRUSION

1. Lightly oil the interior of the cutting cylinder and the guide rods with silicone oil.
2. Weigh six empty containers for the determination of moisture contents of clay trimmings.
3. Ensure that the jack piston is fully retracted.
4. Place the adaptor on top of the jack piston.

5. Loosen the fastening screws and remove the lid of the consolidation cylinder.

6. Invert the consolidation cylinder containing the sample with the cylinder piston still in place.

7. Slide the cylinder piston shaft into the adaptor and set the cylinder on the supporting platform of the main frame.

   Note: Although it is unlikely that the cylinder piston will fall while the cylinder is being inverted, it is suggested to support the piston by hand throughout this step.

8. Loosen the fastening screws and remove the base of the consolidation cylinder.

9. Slide the adjustable cap down the guide rods until the cylinder wall fits into its circular groove.

10. Tighten the two clamping screws to fix the adjustable cap in place.

    Note: At this point, the consolidation cylinder should be secured in place.

11. Pump the jack piston upward slowly and carefully. This causes the sample to be extruded from the cylinder. Stop pumping until the filter stone is clear of the cylinder wall.

12. Remove the filter stone and the filter paper carefully.

13. Slide the cutting cylinder down the guide rods until the cutting edge is about 3cm above the sample.

14. Tighten the two clamping screws to fix the cutting cylinder in place. Jack the sample up against the cutting cylinder. Trim off excess clay.

15. Step 14 is repeated as necessary. Standard procedures, described by Lew(1981), for trimming and building-in clay samples for triaxial tests are then followed.

16. A total of 5 or 6 batches of clay trimmings are to be collected for moisture content determination throughout the extrusion process.

APPENDIX B

COMPUTER PROGRAM LISTINGS

```
REQUESTED OPTIONS: ,EB,,,,OBJ,,MAP,,GOSTMT,,,SIZE(256K),S,NAME(MAIN),OPT(0),LC(654),AD(NONE),FLAG(I),

OPTIONS IN EFFECT: NAME(MAIN) NOOPTIMIZE LINECOUNT(54) SIZE(0256K) AUTODBL(NONE)
                   SOURCE EBCDIC NOLIST NODECK OBJECT MAP NOFORMAT GOSTMT NOXREF NOALC NOANSF NOTERM IBM FLAG(I)

                C
                C
                C
                C
                C      ***************************
                C      *                         *
                C      *          TXCEP          *
                C      *                         *
                C      ***************************
                C
                C
                C      THIS PROGRAM REDUCES DATA FROM TRIAXIAL CONSOLISATION
                C      TEST.  REDUCED DATA INCLUDES :
                C
                C            1)  EFFECTIVE AXIAL STRESS
                C            2)  EFFECTIVE LATERAL STRESS
                C            3)  AXIAL STRAIN
                C            4)  LATERAL STRAIN
                C            5)  VOLUMETRIC STRAIN
                C            6)  EFFECTIVE P
                C            7)  EFFECTIVE Q
                C            8)  VOID RATIO
                C            9)  SPECIFIC VOLUME
                C           10)  SHEAR STRAIN
                C      THE PROGRAM ALSO INCLUDES ENERGY CALCULATION WHICH WAS
                C      WAS BASICALLY THE SAME PROGRAM AS 'ENERGY'.
                C      BESIDES THE FUNCTIONS MENTIONED ABOVE, THIS PROGRAM
                C      ALSO PRODUCES THE FOLLOWING PLOTS :
                C
                C            1)  LOG P VS. V
                C            2)  P VS. Q
                C            3)  SHEAR STRAIN VS. Q
                C            4)  VOL. STRAIN VS. P
                C            5)  LATERAL STRAIN VS. LATERAL STRESS
                C            6)  AXIAL STAIN VS. LATERAL STRESS
                C            7)  LSSV VS. W
                C            8)  AXIAL STRAIN VS. P
                C
                C
                C
                C
    ISN 0002               DIMENSION SIGMA1(90),SIGMA3(90),STRAN1(90),STRAN3(90),VOLSTR(90)
                          &,P(90),Q(90),VR(90),SPVOL(90),DELTAH(90),DELTAV(90),IBUF(4000)
    ISN 0003               DIMENSION JPT(90),ESIMA1(90),ESIMA3(90),ASTRN1(90),RSTRN3(90),
                          1DEVSTM(90),OCTSTM(90),VOLSTN(90),ASIMA1(90),ASIMA3(90),
                          1DESTN1(90),DESTN3(90),LSSV(90),DELENE(90),TOTENE(90),
                          1NSTRN1(90),NSTRN3(90),DELENN(90),TOTENN(90),INCSN1(90),
                          1INCSN3(90),INVOL(90),NVOLSN(90),LSNVE(90),LSNVN(90),SHESTR(90)
    ISN 0004               REAL LSSV,NSTRN1,NSTRN3,NVOLSN,INCSN1,INCSN3,INVOL,LSNVE,LSNVN
    ISN 0005               REAL ISTRN1,ISTRN3
    ISN 0006               REAL IMC,GS,IVR,RATIO,FMC,INTHT,INTVOL
                C
                C
                C      READING IN ESSENTIAL INFORMATION
                C      ::::::::::::::::::::::::::::::::
                C
                C
    ISN 0007               WRITE(6,60)
    ISN 0008               WRITE(6,61)
-----------------------------------------------------------------------------------------------------------------------------

    ISN 0009               READ* ,JSAMP,NHOLE,TDPTHM,BDPTHM
    ISN 0010               IF (NHOLE.LE.0) GO TO 42
    ISN 0012               WRITE(6,630)JSAMP,NHOLE,TDPTHM,BDPTHM
    ISN 0013               GO TO 43
    ISN 0014            42 WRITE(6,631) JSAMP
    ISN 0015            43 READ* ,IMC,GS
    ISN 0016               IVR=GS*IMC/100
    ISN 0017               WRITE(6,100)IMC
    ISN 0018               WRITE(6,101)GS
    ISN 0019               WRITE(6,102)IVR
    ISN 0020               READ* ,INTHT,INTVOL
    ISN 0021               WRITE(6,120)INTHT
    ISN 0022               WRITE(6,121)INTVOL
    ISN 0023               READ* ,JDATES,JDATEE
    ISN 0024               READ* ,M
    ISN 0025               I=1
    ISN 0026             2 IF(I.GT.M) GO TO 3
    ISN 0028               READ* ,SIGMA1(I),SIGMA3(I),DELTAH(I),DELTAV(I)
    ISN 0029               STRAN1(I)=DELTAH(I)/INTHT*100
    ISN 0030               VOLSTR(I)=DELTAV(I)/INTVOL*100
    ISN 0031               STRAN3(I)=(VOLSTR(I)-STRAN1(I))/2
    ISN 0032               SHESTR(I)=(STRAN1(I)-STRAN3(I))*2/3
    ISN 0033               P(I)=(SIGMA1(I)+SIGMA3(I)*2)/3
    ISN 0034               Q(I)=SIGMA1(I)-SIGMA3(I)
    ISN 0035               VR(I)=IVR-VOLSTR(I)/100*(1+IVR)
    ISN 0036               SPVOL(I)=1+VR(I)
    ISN 0037               I=I+1
    ISN 0038               GO TO 2
    ISN 0039             3 RATIO=SIGMA3(M)/SIGMA1(M)
    ISN 0040               WRITE(6,103)RATIO
    ISN 0041               FMC=100*VR(M)/GS
    ISN 0042               WRITE(6,104)FMC
    ISN 0043               WRITE(6,165)JDATES,JDATEE
    ISN 0044               WRITE(6,64)
    ISN 0045               WRITE(6,65)
    ISN 0046               WRITE(6,69)
    ISN 0047               WRITE(6,70)
    ISN 0048               I=1
    ISN 0049             4 IF(I.GT.M) GO TO 5
    ISN 0051               WRITE(6,980)I,SIGMA1(I),SIGMA3(I),STRAN1(I),VOLSTR(I),STRAN3(I),
                          &P(I),Q(I),VR(I),SPVOL(I),SHESTR(I)
    ISN 0052               I=I+1
    ISN 0053               GO TO 4
    ISN 0054             5 L=JSAMP/100
    ISN 0055               NS=JSAMP-L*100
                C
                C
                C      PLOT LOG P VS V
                C      :::::::::::::::
                C
                C
    ISN 0056               CALL PLOTS(IBUF,4000)
    ISN 0057               CALL PLOT(0.0,-5.0,-3)
    ISN 0058               CALL PLOT(0.0,1.5,-3)
    ISN 0059               CALL SCALG(P,5.5,M,1)
    ISN 0060               CALL SCALE(SPVOL,4.0,M,1)
    ISN 0061               CALL LGAXS(0.0,0.0,' LOG P (KPA)',-12,5.5,0.0,
                          &P(M+1),P(M+2))
    ISN 0062               CALL AXIS(0.0,0.0,'SPECIFIC VOLUME',15,4.0,90.0,
                          &SPVOL(M+1),SPVOL(M+2))
    ISN 0063               CALL LGLIN(P,SPVOL,M,1,-1,2,-1)
    ISN 0064               CALL SYMBOL(4.1,3.3,0.21,4HT706,0.0,4)
    ISN 0065               CALL PLOT(0.0,4.0,3)
    ISN 0066               CALL PLOT(5.5,4.0,2)
    ISN 0067               CALL PLOT(5.5,0.0,2)
    ISN 0068               CALL PLOT(5.4,1.0,3)
```

```
ISN 0069                CALL PLOT(5.5,1.0,2)
ISN 0070                CALL PLOT(5.4,2.0,3)
ISN 0071                CALL PLOT(5.5,2.0,2)
ISN 0072                CALL PLOT(5.4,3.0,3)
ISN 0073                CALL PLOT(5.5,3.0,2)
                C
                C
                C       PLOT P VS Q
                C       ===========
                C
                C
ISN 0074                CALL PLOT (0.0,4.5,-3)
ISN 0075                P(M+1)=0.0
ISN 0076                P(M+2)=30.0
ISN 0077                Q(M+1)=0.0
ISN 0078                Q(M+2)=30.0
ISN 0079                CALL AXIS(0.0,0.0,'P (KPA)',-7,5.5,0.0,P(M+1),P(M+2))
ISN 0080                CALL AXIS(0.0,0.0,'Q (KPA)',7,3.5,90.0,Q(M+1),Q(M+2))
ISN 0081                CALL LINE(P,Q,M,1,-1,1)
ISN 0082                CALL SYMBOL(0.5,2.8,0.21,4HT706,0.0,4)
ISN 0083                CALL PLOT(0.0,3.5,3)
ISN 0084                CALL PLOT(5.5,3.5,2)
ISN 0085                CALL PLOT(5.5,0.0,2)
ISN 0086                CALL PLOT(5.4,1.0,3)
ISN 0087                CALL PLOT(5.5,1.0,2)
ISN 0088                CALL PLOT(5.4,2.0,3)
ISN 0089                CALL PLOT(5.5,2.0,2)
ISN 0090                CALL PLOT(5.4,3.0,3)
ISN 0091                CALL PLOT(5.5,3.0,2)
ISN 0092                CALL PLOT(1.0,3.4,3)
ISN 0093                CALL PLOT(1.0,3.5,2)
ISN 0094                CALL PLOT(2.0,3.4,3)
ISN 0095                CALL PLOT(2.0,3.5,2)
ISN 0096                CALL PLOT(3.0,3.4,3)
ISN 0097                CALL PLOT(3.0,3.5,2)
ISN 0098                CALL PLOT(4.0,3.4,3)
ISN 0099                CALL PLOT(4.0,3.5,2)
ISN 0100                CALL PLOT(5.0,3.4,3)
ISN 0101                CALL PLOT(5.0,3.5,2)
ISN 0102                CALL PLOT(12.0,0.0,-3)
                C
                C
                C
                C
ISN 0103                WRITE(6,981)
ISN 0104                WRITE(6,71)
ISN 0105                WRITE(6,72)
ISN 0106                I=1
ISN 0107             6  IF(I.GT.M) GO TO 7
ISN 0109                WRITE(6,982)I,SIGMA1(I),SIGMA3(I),STRAN1(I),STRAN3(I),SPVOL(I)
ISN 0110                I=I+1
ISN 0111                GO TO 6
ISN 0112             7  CONTINUE
                C
                C
                C
ISN 0113                N=M
ISN 0114                PRINT  60
ISN 0115                PRINT  61
ISN 0116                PRINT  63
ISN 0117                PRINT  66
ISN 0118                IF (NHOLE.LE.0) GO TO 48
ISN 0120                PRINT  80,  JSAMP,NHOLE,TDPTHM,BDPTHM
ISN 0121                GO TO 49
ISN 0122             48 WRITE(6,631) JSAMP
ISN 0123             49 PRINT  85, JDATES,JDATEE

--------------------------------------------------------------------------------------------------------

ISN 0124                PRINT  81
ISN 0125                PRINT  82
ISN 0126                PRINT  83
ISN 0127                PRINT  84
ISN 0128                DO     10  I=1,N
                C
                C
                C       READING IN STRESS-STRAIN VALUES
                C       ===============================
                C
                C
ISN 0129                ESIMA1(I)=SIGMA1(I)
ISN 0130                ESIMA3(I)=SIGMA3(I)
ISN 0131                ASTRN1(I)=STRAN1(I)
ISN 0132                VOLSTN(I)=VOLSTR(I)
ISN 0133                JPT(I)=I
ISN 0134                DEVSTM(I)=ESIMA1(I)-ESIMA3(I)
ISN 0135                OCTSTM(I)=(ESIMA1(I)+2*ESIMA3(I))/3
ISN 0136                RSTRN3(I)=(VOLSTN(I)-ASTRN1(I))/2
ISN 0137             10 CONTINUE
ISN 0138                L=N-1
ISN 0139                NSTRN1(1)=ASTRN1(1)/(1-ASTRN1(1)/200)
ISN 0140                NVOLSN(1)=VOLSTN(1)/(1-VOLSTN(1)/200)
ISN 0141                NSTRN3(1)=(NVOLSN(1)-NSTRN1(1))/2
ISN 0142                DO     12  II=1,L
ISN 0143                INCSN1(II)=(ASTRN1(II+1)-ASTRN1(II))/
                      1             (1-(ASTRN1(II+1)+ASTRN1(II))/200)
ISN 0144                INVOL(II)=(VOLSTN(II+1)-VOLSTN(II))/
                      1            (1-(VOLSTN(II+1)+VOLSTN(II))/200)
ISN 0145                INCSN3(II)=(INVOL(II)-INCSN1(II))/2
ISN 0146            12  CONTINUE
ISN 0147                DO     13   K=1,L
ISN 0148                NSTRN1(K+1)=INCSN1(K)+NSTRN1(K)
ISN 0149                NSTRN3(K+1)=INCSN3(K)+NSTRN3(K)
ISN 0150                NVOLSN(K+1)=INVOL(K)+NVOLSN(K)
ISN 0151            13  CONTINUE
ISN 0152                OSIMA1=ESIMA1(1)
ISN 0153                OSIMA3=ESIMA3(1)
ISN 0154                OSTRN1=ASTRN1(1)
ISN 0155                OSTRN3=RSTRN3(1)
ISN 0156                ISTRN1=NSTRN1(1)
ISN 0157                ISTRN3=NSTRN3(1)
ISN 0158                DO     11  I=1,N
ISN 0159                LSSV(I)=SQRT((ESIMA1(I)-OSIMA1)**2+2*(ESIMA3(I)-OSIMA3)**2)
ISN 0160                LSNVE(I)=SQRT((ASTRN1(I)-OSTRN1)**2+2*(RSTRN3(I)-OSTRN3)**2)
ISN 0161                LSNVN(I)=SQRT((NSTRN1(I)-ISTRN1)**2+2*(NSTRN3(I)-ISTRN3)**2)
ISN 0162            11  CONTINUE
                C
                C
                C       ENERGY CALCULATIONS
                C       ===================
                C
                C
ISN 0163                M=N-1
ISN 0164                DO     20  J=1,M
ISN 0165                ASIMA1(J)=(ESIMA1(J+1)+ESIMA1(J))/2
ISN 0166                ASIMA3(J)=(ESIMA3(J+1)+ESIMA3(J))/2
ISN 0167                DESTN1(J)=ASTRN1(J+1)-ASTRN1(J)
ISN 0168                DESTN3(J)=RSTRN3(J+1)-RSTRN3(J)
ISN 0169                DELENE(J)=(ASIMA1(J)*DESTN1(J)+2*ASIMA3(J)*DESTN3(J))/100
ISN 0170                DELENN(J)=(ASIMA1(J)*(NSTRN1(J+1)-NSTRN1(J))   +
                     1              2*ASIMA3(J)*(NSTRN3(J+1)-NSTRN3(J)))/100
ISN 0171             20 CONTINUE
ISN 0172                TOTENE(1)=0.0
ISN 0173                TOTENN(1)=0.0
ISN 0174                DO     30 K=1,M
```

```
ISN 0175                TOTENE(K+1)=DELENE(K)+TOTENE(K)
ISN 0176                TOTENN(K+1)=DELENN(K)+TOTENN(K)
ISN 0177             30 CONTINUE
                  C
                  C
                  C     PRINT CALCULATED RESULTS
                  C     ========================
                  C
                  C
ISN 0178                DO     40 KK=1,N
ISN 0179                PRINT  90, JPT(KK),ESIMA1(KK),ESIMA3(KK),DEVSTM(KK),OCTSTM(KK),
                       1ASTRN1(KK),RSTRN3(KK),VOLSTN(KK),LSSV(KK),LSNVE(KK),TOTENE(KK)
ISN 0180                IF (KK.EQ.N)  GO TO 40
ISN 0182                PRINT  91, DELENE(KK)
ISN 0183             40 CONTINUE
ISN 0184                PRINT  60
ISN 0185                PRINT  61
ISN 0186                PRINT  63
ISN 0187                PRINT  73
ISN 0188                IF (NHOLE.LE.0) GO TO 46
ISN 0190                PRINT  80,  JSAMP,NHOLE,TDPTHM,BDPTHM
ISN 0191                GO TO 47
ISN 0192             46 WRITE(6,631) JSAMP
ISN 0193             47 PRINT  85, JDATES,JDATEE
ISN 0194                PRINT  81
ISN 0195                PRINT  82
ISN 0196                PRINT  83
ISN 0197                PRINT  84
ISN 0198                DO     41 JJ=1,N
ISN 0199                PRINT  90, JPT(JJ),ESIMA1(JJ),ESIMA3(JJ),DEVSTM(JJ),OCTSTM(JJ),
                       1NSTRN1(JJ),NSTRN3(JJ),NVOLSN(JJ),LSSV(JJ),LSNVN(JJ),TOTENN(JJ)
ISN 0200                IF (JJ.EQ.N)  GO TO 41
ISN 0202                PRINT  91, DELENN(JJ)
ISN 0203             41 CONTINUE
ISN 0204                M=M+1
                  C
                  C
                  C     SHEAR STRAIN VS SHEAR STRESS PLOT
                  C     =================================
                  C
                  C
ISN 0205                CALL PLOT(0.0,-5.0,-3)
ISN 0206                CALL SCALE(SHESTR,4.5,M,1)
ISN 0207                SHESTR(M+1)=0.0
ISN 0208                Q(M+1)=0.0
ISN 0209                Q(M+2)=30.0
ISN 0210                CALL AXIS(0.0,0.0,'SHEAR STRAIN (%)',-16,6.0,0.0,
                       &SHESTR(M+1),SHESTR(M+2))
ISN 0211                CALL AXIS(0.0,0.0,'SHEAR STRESS , Q (KPA)',22,4.0,90.0,
                       &Q(M+1),Q(M+2))
ISN 0212                CALL LINE(SHESTR,Q,M,1,-1,0)
ISN 0213                CALL SYMBOL(0.5,3.3,0.21,4HT706,0.0,4)
ISN 0214                CALL PLOT(0.0,4.0,3)
ISN 0215                CALL PLOT(6.0,4.0,2)
ISN 0216                CALL PLOT(6.0,0.0,2)
ISN 0217                CALL PLOT(5.9,1.0,3)
ISN 0218                CALL PLOT(6.0,1.0,2)
ISN 0219                CALL PLOT(5.9,2.0,3)
ISN 0220                CALL PLOT(6.0,2.0,2)
ISN 0221                CALL PLOT(5.9,3.0,3)
ISN 0222                CALL PLOT(6.0,3.0,2)
ISN 0223                CALL PLOT(1.0,3.9,3)
ISN 0224                CALL PLOT(1.0,4.0,2)
ISN 0225                CALL PLOT(2.0,3.9,3)
ISN 0226                CALL PLOT(2.0,4.0,2)
ISN 0227                CALL PLOT(3.0,3.9,3)

--------------------------------------------------------------------------------------------

ISN 0228                CALL PLOT(3.0,4.0,2)
ISN 0229                CALL PLOT(4.0,3.9,3)
ISN 0230                CALL PLOT(4.0,4.0,2)
ISN 0231                CALL PLOT(5.0,3.9,3)
ISN 0232                CALL PLOT(5.0,4.0,2)
                  C
                  C
                  C     PLOT VOLUME STRAIN VS P
                  C     =======================
                  C
                  C
ISN 0233                CALL SCALE(VOLSTR,4.5,M,1)
ISN 0234                VOLSTR(M+1)=0.0
ISN 0235                P(M+1)=0.0
ISN 0236                P(M+2)=30.0
ISN 0237                CALL PLOT(0.0,4.5,-3)
ISN 0238                CALL AXIS(0.0,0.0,'VOLUME STRAIN (%)',-17,6.0,0.0,
                       &VOLSTR(M+1),VOLSTR(M+2))
ISN 0239                CALL AXIS(0.0,0.0,'P (KPA)',7,4.0,90.0,P(M+1),P(M+2))
ISN 0240                CALL LINE(VOLSTR,P,M,1,-1,5)
ISN 0241                CALL SYMBOL(0.5,3.3,0.21,4HT706,0.0,4)
ISN 0242                CALL PLOT(0.0,4.0,3)
ISN 0243                CALL PLOT(6.0,4.0,2)
ISN 0244                CALL PLOT(6.0,0.0,2)
ISN 0245                CALL PLOT(5.9,1.0,3)
ISN 0246                CALL PLOT(6.0,1.0,2)
ISN 0247                CALL PLOT(5.9,2.0,3)
ISN 0248                CALL PLOT(6.0,2.0,2)
ISN 0249                CALL PLOT(5.9,3.0,3)
ISN 0250                CALL PLOT(6.0,3.0,2)
ISN 0251                CALL PLOT(1.0,3.9,3)
ISN 0252                CALL PLOT(1.0,4.0,2)
ISN 0253                CALL PLOT(2.0,3.9,3)
ISN 0254                CALL PLOT(2.0,4.0,2)
ISN 0255                CALL PLOT(3.0,3.9,3)
ISN 0256                CALL PLOT(3.0,4.0,2)
ISN 0257                CALL PLOT(4.0,3.9,3)
ISN 0258                CALL PLOT(4.0,4.0,2)
ISN 0259                CALL PLOT(5.0,3.9,3)
ISN 0260                CALL PLOT(5.0,4.0,2)
ISN 0261                CALL PLOT(12.0,0.0,-3)
                  C
                  C
                  C     PLOT LATERAL STRAIN VS LATERAL STRESS
                  C     =====================================
                  C
                  C
ISN 0262                CALL PLOT(0.0,-4.5,-3)
ISN 0263                CALL SCALE(STRAN3,4.5,M,1)
ISN 0264                CALL SCALE(SIGMA3,3.0,M,1)
ISN 0265                STRAN3(M+1)=0.0
ISN 0266                SIGMA3(M+1)=0.0
ISN 0267                CALL AXIS(0.0,0.0,'LATERAL STRAIN (%)',-18,6.0,0.0,
                       &STRAN3(M+1),STRAN3(M+2))
ISN 0268                CALL AXIS(0.0,0.0,'LATERAL STRESS (KPA)',20,3.0,90.0,
                       &SIGMA3(M+1),SIGMA3(M+2))
ISN 0269                CALL LINE(STRAN3,SIGMA3,M,1,-1,10)
ISN 0270                CALL SYMBOL(0.5,2.3,0.21,4HT706,0.0,4)
ISN 0271                CALL PLOT(0.0,3.0,3)
ISN 0272                CALL PLOT(6.0,3.0,2)
ISN 0273                CALL PLOT(6.0,0.0,2)
ISN 0274                CALL PLOT(5.9,1.0,3)
ISN 0275                CALL PLOT(6.0,1.0,2)
ISN 0276                CALL PLOT(5.9,2.0,3)
ISN 0277                CALL PLOT(6.0,2.0,2)
ISN 0278                CALL PLOT(1.0,2.9,3)
```

```
ISN 0279            CALL PLOT(1.0,3.0,2)
ISN 0280            CALL PLOT(2.0,2.9,3)
ISN 0281            CALL PLOT(2.0,3.0,2)
ISN 0282            CALL PLOT(3.0,2.9,3)
ISN 0283            CALL PLOT(3.0,3.0,2)
ISN 0284            CALL PLOT(4.0,2.9,3)
ISN 0285            CALL PLOT(4.0,3.0,2)
ISN 0286            CALL PLOT(5.0,2.9,3)
ISN 0287            CALL PLOT(5.0,3.0,2)
              C
              C
              C     PLOT AXIAL STRAIN VS AXIAL STRESS
              C     :::::::::::::::::::::::::::::::::
              C
              C
ISN 0288            CALL SCALE(STRAN1,6.0,M,1)
ISN 0289            CALL SCALE(SIGMA1,5.0,M,1)
ISN 0290            STRAN1(M+1)=0.0
ISN 0291            SIGMA1(M+1)=0.0
ISN 0292            CALL PLOT(0.0,3.5,-3)
ISN 0293            CALL AXIS(0.0,0.0,'AXIAL STRAIN (%)',-16,6.0,0.0,
                   &STRAN1(M+1),STRAN1(M+2))
ISN 0294            CALL AXIS(0.0,0.0,'SIGMA1 (KPA)',12,5.0,90.0,SIGMA1(M+1),
                   &SIGMA1(M+2))
ISN 0295            CALL LINE(STRAN1,SIGMA1,M,1,-1,12)
ISN 0296            CALL SYMBOL(0.5,4.3,0.21,4HT706,0.0,4)
ISN 0297            CALL PLOT(0.0,5.0,3)
ISN 0298            CALL PLOT(6.0,5.0,2)
ISN 0299            CALL PLOT(6.0,0.0,2)
ISN 0300            CALL PLOT(5.9,1.0,3)
ISN 0301            CALL PLOT(6.0,1.0,2)
ISN 0302            CALL PLOT(5.9,2.0,3)
ISN 0303            CALL PLOT(6.0,2.0,2)
ISN 0304            CALL PLOT(5.9,3.0,3)
ISN 0305            CALL PLOT(6.0,3.0,2)
ISN 0306            CALL PLOT(5.9,4.0,3)
ISN 0307            CALL PLOT(6.0,4.0,2)
ISN 0308            CALL PLOT(1.0,4.9,3)
ISN 0309            CALL PLOT(1.0,5.0,2)
ISN 0310            CALL PLOT(2.0,4.9,3)
ISN 0311            CALL PLOT(2.0,5.0,2)
ISN 0312            CALL PLOT(3.0,4.9,3)
ISN 0313            CALL PLOT(3.0,5.0,2)
ISN 0314            CALL PLOT(4.0,4.9,3)
ISN 0315            CALL PLOT(4.0,5.0,2)
ISN 0316            CALL PLOT(5.0,4.9,3)
ISN 0317            CALL PLOT(5.0,5.0,2)
ISN 0318            CALL PLOT(12.0,1.0,-3)
              C
              C
              C     PLOT LSSV VS W
              C     ::::::::::::::
              C
              C
ISN 0319            CALL SCALE(LSSV,6.0,M,1)
ISN 0320            CALL SCALE(TOTENE,4.0,M,1)
ISN 0321            CALL PLOT(0.0,-4.5,-3)
ISN 0322            CALL AXIS(0.0,0.0,'LSSV (KPA)',-10,6.0,0.0,
                   &LSSV(M+1),LSSV(M+2))
ISN 0323            CALL AXIS(0.0,0.0,'W  (KJ/M**3)',12,4.0,90.0,
                   &TOTENE(M+1),TOTENE(M+2))
ISN 0324            CALL LINE(LSSV,TOTENE,M,1,-1,11)
ISN 0325            CALL SYMBOL(0.5,3.3,0.21,4HT706,0.0,4)
ISN 0326            CALL PLOT(0.0,4.0,3)
ISN 0327            CALL PLOT(6.0,4.0,2)
ISN 0328            CALL PLOT(6.0,0.0,2)
---------------------------------------------------------------------------------------------------------------------
ISN 0329            CALL PLOT(5.9,1.0,3)
ISN 0330            CALL PLOT(6.0,1.0,2)
ISN 0331            CALL PLOT(5.9,2.0,3)
ISN 0332            CALL PLOT(6.0,2.0,2)
ISN 0333            CALL PLOT(5.9,3.0,3)
ISN 0334            CALL PLOT(6.0,3.0,2)
ISN 0335            CALL PLOT(1.0,3.9,3)
ISN 0336            CALL PLOT(1.0,4.0,2)
ISN 0337            CALL PLOT(2.0,3.9,3)
ISN 0338            CALL PLOT(2.0,4.0,2)
ISN 0339            CALL PLOT(3.0,3.9,3)
ISN 0340            CALL PLOT(3.0,4.0,2)
ISN 0341            CALL PLOT(4.0,3.9,3)
ISN 0342            CALL PLOT(4.0,4.0,2)
ISN 0343            CALL PLOT(5.0,3.9,3)
ISN 0344            CALL PLOT(5.0,4.0,2)
              C
              C
              C     PLOT AXIAL STRAIN VS P
              C     ::::::::::::::::::::::
              C
              C
ISN 0345            CALL PLOT(0.0,4.5,-3)
ISN 0346            CALL AXIS(0.0,0.0,'AXIAL STRAIN (%)',-16,6.0,0.0,
                   &STRAN1(M+1),STRAN1(M+2))
ISN 0347            CALL AXIS(0.0,0.0,'P (KPA)',7,4.0,90.0,P(M+1),
                   &P(M+2))
ISN 0348            CALL LINE(STRAN1,P,M,1,-1,3)
ISN 0349            CALL SYMBOL(0.5,3.3,0.21,4HT706,0.0,4)
ISN 0350            CALL PLOT(0.0,4.0,3)
ISN 0351            CALL PLOT(6.0,4.0,2)
ISN 0352            CALL PLOT(6.0,0.0,2)
ISN 0353            CALL PLOT(5.9,1.0,3)
ISN 0354            CALL PLOT(6.0,1.0,2)
ISN 0355            CALL PLOT(5.9,2.0,3)
ISN 0356            CALL PLOT(6.0,2.0,2)
ISN 0357            CALL PLOT(5.9,3.0,3)
ISN 0358            CALL PLOT(6.0,3.0,2)
ISN 0359            CALL PLOT(1.0,3.9,3)
ISN 0360            CALL PLOT(1.0,4.0,2)
ISN 0361            CALL PLOT(2.0,3.9,3)
ISN 0362            CALL PLOT(2.0,4.0,2)
ISN 0363            CALL PLOT(3.0,3.9,3)
ISN 0364            CALL PLOT(3.0,4.0,2)
ISN 0365            CALL PLOT(4.0,3.9,3)
ISN 0366            CALL PLOT(4.0,4.0,2)
ISN 0367            CALL PLOT(5.0,3.9,3)
ISN 0368            CALL PLOT(5.0,4.0,2)
ISN 0369            CALL PLOT(12.0,0.0,999)
ISN 0370            STOP
ISN 0371        120 FORMAT(T13,38H INITIAL HEIGHT OF SAMPLE            :  ,F5.2,3H CM)
ISN 0372        121 FORMAT(T13,38H INITIAL VOLUME OF SAMPLE            :  ,F6.2,3H CC)
ISN 0373        103 FORMAT(T13,38H EFFECTIVE PRINCIPAL STRESS RATIO  :  ,F4.2)
ISN 0374        100 FORMAT(T13,
                   1        38H INITIAL MOISTURE CONTENT            :  ,F5.1,8H PERCENT)
ISN 0375        101 FORMAT(T13,38H SPECIFIC GRAVITY OF SOIL            :  ,F4.2)
ISN 0376        102 FORMAT(T13,38H INITIAL VOID RATIO                  :  ,F6.3)
ISN 0377        104 FORMAT(T13,
                   1        38H FINAL MOISTURE CONTENT              :  ,F5.1,8H PERCENT
                   &//)
ISN 0378         60 FORMAT (1H1,10(/),T13,23H UNIVERSITY OF MANITOBA)
ISN 0379         61 FORMAT (T13,26H SOIL MECHANICS LABORATORY//)
ISN 0380        165 FORMAT(T13,28H TX.  CONSOLIDATION    START,  I10,5H     ,
                   13HEND, I10              )
ISN 0381         64 FORMAT(T13,29H TRIAXIAL CONSOLIDATION TEST )
ISN 0382         65 FORMAT(T13,29H ::::::::::::::::::::::::::: ,///)
```

```
   ISN 0383          69 FORMAT(///,T13,48H  PT  EFFECT   EFFECT  STRAIN1   VOLUME  STRAIN3
                       &,45H   EFFECT      Q        VOID       V      SHEAR )
   ISN 0384          70 FORMAT(T13,48H       SIGMA1   SIGMA3            STRAIN           ,
                       &45H    P                  RATIO             STRAIN//)
   ISN 0385          71 FORMAT(7(/),T13,44H SUMMARY OF ESSENTIAL RESULTS STORED IN FILE)
   ISN 0386          72 FORMAT(6(/),T13,46H  PT  SIGMA1   SIGMA3   STRAIN1   STRAIN3       ,
                       &1HV//)
   ISN 0387         630 FORMAT(T13,15H SAMPLE NO. = T,I4,5X,11H HOLE NO. = ,I4,5X,
                       1  9H DEPTH = ,F6.2,11H METRES TO ,F6.2,8H METRES )
   ISN 0388         631 FORMAT(T13,15H SAMPLE NO. = T,I4,5X,'(REMOULDED SAMPLE)')
   ISN 0389         980 FORMAT(T13,I4,2X,F6.2,3X,F6.2,3X,F6.3,3X,F6.3,3X,F6.3,3X,F6.2,3X,
                       &F6.2,3X,F6.3,3X,F6.3,3X,F6.3)
   ISN 0390         982 FORMAT(T13,I4,2X,F6.2,3X,F6.2,3X,F6.3,3X,F6.3,3X,F6.3)
   ISN 0391         981 FORMAT(1H1)
   ISN 0392          63 FORMAT(T13,20H ENERGY CALCULATIONS/)
   ISN 0393          66 FORMAT(T13,31H ****  ENGINEERING STRAIN  ****//)
   ISN 0394          73 FORMAT(T13,31H ****    NATURAL STRAIN    ****//)
   ISN 0395          80 FORMAT(T13,15H SAMPLE NO. = T,I4,5X,11H HOLE NO. = ,I4,5X,
                       1  9H DEPTH = ,F6.2,11H METRES TO ,F6.2,8H METRES  //)
   ISN 0396          81 FORMAT(T13,47H  PT   EFFECT   EFFECT   DEV     EFFECT   AXIAL,
                       150H   RADIAL   VOL       LSSV   LSNV    DELTA    TOTAL)
   ISN 0397          82 FORMAT(T13,46H       SIGMA1   SIGMA3   STRESS  OCT      STRAIN,
                       151H  STRAIN   STRAIN                ENERGY   ENERGY )
   ISN 0398          83 FORMAT(T13,45H       KPA      KPA      KPA     STRESS     %,
                       154H      %         %       KPA      %      KN-M/VOL KN-M/VOL)
   ISN 0399          84 FORMAT(T13,36H                                     KPA/)
   ISN 0400          90 FORMAT(T13,I4,2X,F6.1,3X,F6.1,2X,F6.1,3X,F6.1,4X,F6.3,2X,F6.3,
                       13X,F6.3,2X,F6.1,2X,F4.1,11X,F7.3)
   ISN 0401          91 FORMAT(T13,81X,F7.3)
   ISN 0402          85 FORMAT(T13,22H TEST RESULTS    START,  I10,5H      ,
                       13HEND, I10      ///)
   ISN 0403               END


                                                        /      MAIN /     SIZE OF PROGRAM 00ADAC HEXADECIMAL BYTES

       NAME     TAG   TYPE  ADD.          NAME     TAG   TYPE  ADD.          NAME     TAG   TYPE  ADD.          NAME     TAG   TYPE  ADD.
          I SFA       I*4   001474           J SF        I*4   001478           K SF        I*4   00147C           L SF        I*4   001480
          M SFA       I*4   001484           N SF        I*4   001488           P SFA       R*4   0014E8           Q SFA       R*4   001650
         GS SF        R*4   00148C          II SF        I*4   001490          JJ SF        I*4   001494          KK SF        I*4   001498
         NS S         I*4   00149C          VR SF        R*4   0017B8         FMC SF        R*4   0014A0         IMC SF        R*4   0014A4
        IVR SF        R*4   0014A8         JPT SF        I*4   001924        AXIS SF   XF         000000        IBUF SFA       I*4   001A8C
       LINE SF   XF         000000        LSSV SFA       R*4   00590C        PLOT SF   XF         000000        SQRT  F   XF  R*4   000000
      INTHT SF        R*4   0014AC       INVOL SF        R*4   005A74       JSAMP SF        I*4   0014B0       LGAXS SF   XF         000000
      LGLIN SF   XF         000000       LSNVE SF        R*4   005BDC       LSNVN SF        R*4   005D44       NHOLE SF        I*4   0014B4
      PLOTS SF   XF         000000       RATIO SF        R*4   0014B8       SCALE SF   XF         000000       SCALG SF   XF         000000
      SPVOL SFA       R*4   005EAC      ASIMA1 SF        R*4   006014      ASIMA3 SF        R*4   00617C      ASTRN1 SFA       R*4   0062E4
     BDPTHM SF        R*4   0014BC      DELENE SF        R*4   00644C      DELENN SF        R*4   0065B4      DELTAH SF        R*4   00671C
     DELTAV SF        R*4   006884      DESTN1 SF        R*4   0069EC      DESTN3 SF        R*4   006B54      DEVSTM SF        R*4   006CBC
     ESIMA1 SFA       R*4   006E24      ESIMA3 SFA       R*4   006F8C      IBCOM#  F   XF  I*4   000000      INCSN1 SF        R*4   0070F4
     INCSN3 SF        R*4   00725C      INTVOL SF        R*4   0014C0      ISTRN1 SFA       R*4   0014C4      ISTRN3 SFA       R*4   0014C8
     JDATEE SF        I*4   0014CC      JDATES SF        I*4   0014D0      LDFIO#  F   XF  I*4   000000      NSTRN1 SFA       R*4   0073C4
     NSTRN3 SFA       R*4   00752C      NVOLSN SF        R*4   007694      OCTSTM SF        R*4   0077FC      OSIMA1 SFA       R*4   0014D4
     OSIMA3 SFA       R*4   0014D8      OSTRN1 SFA       R*4   0014DC      OSTRN3 SFA       R*4   0014E0      RSTRN3 SFA       R*4   007964
     SHESTR SFA       R*4   007ACC      SIGMA1 SFA       R*4   007C34      SIGMA3 SFA       R*4   007D9C      STRAN1 SFA       R*4   007F04
     STRAN3 SFA       R*4   00806C      SYMBOL SF   XF         000000      TDPTHM SF        R*4   0014E4      TOTENE SFA       R*4   0081D4
     TOTENN SF        R*4   00833C      VOLSTN SF        R*4   0084A4      VOLSTR SFA       R*4   00860C


  SOURCE STATEMENT LABELS

    LABEL  ISN   ADDR              LABEL  ISN   ADDR              LABEL  ISN   ADDR              LABEL  ISN   ADDR
       42   14  008966                43   15  008984                 2   26  008AB0                 3   39  008CD0
        4   49  008DC4                 5   54  008EAE                 6  107  0092E4                 7  112  00937A
       48  122  00941A                49  123  009438                10  137  009618                12  146  0097DE

----------------------------------------------------------------------------------------------------------------------------------------

       13  151  0098A4                11  162  009A6C                20  171  009C96                30  177  009D40
       40  183  009E78                46  192  009F26                47  193  009F44                41  203  00A0CC

  COMPILER GENERATED LABELS

    LABEL  ISN   ADDR              LABEL  ISN   ADDR              LABEL  ISN   ADDR              LABEL  ISN   ADDR
   100000    1  0088C4            100001   12  00892C            100002   28  008ABE            200001   37  008CBE
   100003   51  008DD2            200002   65  008FF2            200003   81  009156            200004   96  009232
   100004  109  0092F2            100005  120  0093E0            100006  129  0094B4            100007  138  00962E
   100008  143  0096B6            100009  147  0097F4            100010  148  0097FC            100011  152  0098BA
   100012  159  0098FE            100013  163  009A82            100014  165  009A96            100015  172  009CAC
   100016  175  009CC8            100017  178  009D56            100018  179  009D5E            100019  182  009E4E
   100020  184  009E8E            100021  190  009EEC            100022  199  009FC0            100023  202  00A0A2
   100024  204  00A0E2            200005  217  00A230            200006  233  00A310            200007  245  00A448
   200008  261  00A528            200009  272  00A664            200010  288  00A744            200011  299  00A86C
   200012  315  00A94C            200013  326  00AA88            200014  342  00AB68            200015  353  00AC8C
   200016  369  00AD6C

  FORMAT STATEMENT LABELS

    LABEL  ISN   ADDR              LABEL  ISN   ADDR              LABEL  ISN   ADDR              LABEL  ISN   ADDR
      120  371  000028               121  372  00005C               103  373  000090               100  374  0000BF
      101  375  0000F8               102  376  000127               104  377  000156                60  378  000191
       61  379  0001B5               165  380  0001D7                64  381  000209                65  382  00022C
       69  383  000252                70  384  0002BA                71  385  000321                72  386  000357
      630  387  000394               631  388  0003E6               980  389  000413               982  390  00044B
      981  391  00046A                63  392  00046F                66  393  00048A                73  394  0004B1
       80  395  0004D8                81  396  00052C                82  397  000595                83  398  000600
       84  399  00066B                90  400  000696                91  401  0006CE                85  402  0006D7

*OPTIONS IN EFFECT*NAME(MAIN) NOOPTIMIZE LINECOUNT(54) SIZE(0256K) AUTODBL(NONE)

*OPTIONS IN EFFECT*SOURCE EBCDIC NOLIST NODECK OBJECT MAP NOFORMAT GOSTMT NOXREF NOALC NOANSF NOTERM IBM FLAG(I)

*STATISTICS*     SOURCE STATEMENTS =      402, PROGRAM SIZE =     44460, SUBPROGRAM NAME =  MAIN

*STATISTICS*  NO  DIAGNOSTICS GENERATED

****** END OF COMPILATION ******                                          52K BYTES OF CORE NOT USED
```

```
REQUESTED OPTIONS: ,EB,,,,OBJ,,MAP,,GOSTMT,,,SIZE(256K),S,NAME(MAIN),OPT(0),LC(654),AD(NONE),FLAG(I),

OPTIONS IN EFFECT: NAME(MAIN) NOOPTIMIZE LINECOUNT(54) SIZE(0256K) AUTODBL(NONE)
                   SOURCE EBCDIC NOLIST NODECK OBJECT MAP NOFORMAT GOSTMT NOXREF NOALC NOANSF NOTERM IBM FLAG(I)

               C
               C
               C
               C
               C
               C      ******************************
               C      *                            *
               C      *          USHEARP           *
               C      *                            *
               C      ******************************
               C
               C
               C
               C
               C      THIS PROGRAM IS A MODIFICATION OF THE PROGRAM 'TRIAXIAL'
               C      WHICH IS ABLE TO REDUCE DATA FROM UNDRAINED SHEAR TEST.
               C      'USHEARP' HAS TWO ADDITIONAL FEATURES :
               C          (1) HANDLE BOTH NATURAL AND REMOULDED SAMPLES
               C          (2) PRODUCE 3 PLOTS :
               C                (A)  NOM. HALF DEV.STRESS VS. AXIAL STRAIN
               C                (B)  EFF. STRESS RATIO VS. AXIAL STRAIN
               C                (C)  PWP CHANGE VS. AXIAL STRAIN
               C
               C
               C
               C      TERMS AND DEFINITIONS
               C      *********************
               C
               C
               C      NOTE: (1) IN THIS VERSION OF THE PROGRAM
               C
               C                  (1) SAMPLE DIMENSIONS ARE READ IN CENTIMETRES
               C
               C                  (2) SAMPLE DEPTHS ARE READ IN METRES
               C
               C                  (3) PRESSURES ARE READ IN KPA
               C
               C                  (4) CONSTANT (DEAD) LOAD IS READ IN NEWTONS
               C
               C                  (5) PROVING RING FACTOR IS READ IN N/DIV
               C
               C                  (6) DIAL GAUGE READING IS READ IN UNITS OF 0.01 MM
               C
               C
               C      NOTE: (2)
               C
               C                  CONTROL CARDS ARE AS FOLLOWS:
               C
               C                    **********************
               C                    *                    *
               C                    *       PROGRAM      *
               C                    *                    *
               C                    **********************
               C
               C                    **********************
               C                    *                    *
               C                    *         DATA       *
               C                    *                    *
               C                    **********************
-----------------------------------------------------------------------------------------------------------------------------------

               C
               C                    **********************
               C                    *                    *
               C      CONTROL CARDS *  -1  0  0  0  0  0 *   INDICATES END OF DATA PAC
               C                    *                    *
               C                    *--------------------*
               C                    *                    *
               C                    *   0                *   PRINTS CALCULATED RESULTS
               C                    *                    *
               C                    *--------------------*
               C                    *                    *
               C                    *   0                *   SEARCHES FOR NEW DATA
               C                    *                    *
               C                    *--------------------*
               C                    *  -1  0  0  0       *   STOPS PROGRAM
               C                    *                    *
               C                    **********************
               C
               C
               C
               C
               C      A       =  POREWATER PRESSURE PARAMETER
               C      AA      =  SCALE FACTOR FOR DIAL GAUGES NOT READ IN UNITS OF 0.01M
               C      APISTM  =  PISTON AREA
               C      AREAM   =  CURRENT SAMPLE AREA AT ANY STAGE OF THE TEST
               C
               C      B       =  COUNTING INDEX ( CONTROL CARD )
               C      BDPTHM  =  DEPTH OF SAMPLE (BOTTOM)
               C
               C      CELLPR  =  CELL PRESSURE
               C      CLOADM  =  CONSTANT LOAD (DEAD LOAD)
               C      CONAXM  =  CONSOLIDATION AXIAL STRESS
               C
               C      DEVSNM  =  NORMALIZED DEVIATOR STRESS
               C      DEVSNO  =  INITIAL DEVIATOR STRESS ( NORMALIZED )
               C      DLTAUM  =  CHANGE IN POREWATER PRESSURE
               C      DLTUNM  =  NORMALIZED CHANGE IN POREWATER PRESSURE
               C      DVSTRM  =  DEVIATOR STRESS
               C
               C      ECELPM  =  EFFECTIVE CELL PRESSURE ( EFF. SIGMA 3 )
               C      EFSTRM  =  EFFECTIVE AXIAL STRESS (EFF. SIGMA 1 )
               C      EFSRTO  =  EFFECTIVE STRESS RATIO
               C      F       =  ( 1-APISTM/AREAM )
               C
               C      HDVSTN  =  NORMALIZED HALF DEVIATOR STRESS
               C      HDVSTR  =  HALF DEVIATOR STRESS
               C
               C      I       =  COUNTING INDEX
               C
               C      JDATEE  =  ENDING DATE OF SHEAR TEST
               C      JDATES  =  STARTING DATE OF SHEAR TEST
               C      JPT     =  POINT WHERE READING IS TAKEN
               C      JPTX    =  POINT WHERE READING IS TAKEN
               C      JSAMP   =  SAMPLE NO.
               C      JTIME   =  TIME
               C
               C      M       =  COUNTING INDEX ( TOTAL NO. OF POINTS IN TEST SERIES )
               C
               C      NHOLE   =  HOLE NO.
               C
               C      OCTSNM  =  NORMALIZED EFFECTIVE NORMAL OCTAHEDRAL STRESS
               C      OCTSTM  =  EFFECTIVE NORMAL OCTAHEDRAL STRESS
               C
               C      PCONPM  =  PRE-CONSOLIDATION STRESS
               C      PCSTR   =  PERCENT (%) STRAIN
               C      PCSTRN  =  PERCENT (%) STRAIN
```

```
               C      PFCTRM  =  PROVING RING FACTOR
               C      PRING   =  PROVING RING READING
               C      PWP     =  POREWATER PRESSURE DURING SHEAR
               C      PWPOM   =  INITIAL POREWATER PRESSURE
               C      PWPRM   =  POREWATER PRESSURE DURING SHEAR
               C
               C      RATIO   =  EFFECTIVE PRINCIPAL STRESS RATIO
               C      RDIAL   =  DIAL READING
               C      RDILOM  =  INITIAL DIAL READING
               C
               C      SAREAM  =  SAMPLE AREA AFTER CONSOLIDATION
               C      SHGHTM  =  SAMPLE HEIGHT AFTER CONSOLIDATION
               C      STRAIN  =  AXIAL STRAIN
               C      STRESM  =  TOTAL AXIAL STRESS ( SIGMA 1 )
               C      SVOLM   =  SAMPLE VOLUME AFTER CONSOLIDATION
               C
               C      TDPTHM  =  DEPTH OF SAMPLE (TOP)
               C
               C      X       =  AXIAL STRESS INCREASE DUE TO CHANGE IN CELL PRESSURE
               C      XLOAD   =  AXIAL LOAD
               C      XNRMSM  =  NORMALIZING STRESS
               C
               C      Y       =  AXIAL STRESS DUE TO PROVING RING AND DEAD LOADS
               C
               C
               C
               C
               C      START READING IN ESSENTIAL INFORMATION
               C      ======================================
               C
ISN 0002              DIMENSION JPTX(90),STRAIN(90),PCSTRN(90),DEVSNM(90),A(90),
                     1OCTSNM(90),DLTUNM(90),HDVSTN(90),EFSRTO(90),IBUF(4000),
                     &DVSTRM(90),OCTSTM(90)
ISN 0003            1 READ* ,JSAMP,NHOLE,TDPTHM,BDPTHM
ISN 0004              IF (JSAMP)2,3,3
ISN 0005            2 CALL EXIT
ISN 0006            3 WRITE(6,60)
ISN 0007              LLL=JSAMP/100
ISN 0008              NS=JSAMP-LLL*100
ISN 0009              WRITE(6,61)
ISN 0010              READ* ,SHGHTM,SVOLM,SAREAM,RDILOM
ISN 0011              READ* ,AA
ISN 0012              READ* ,CLOADM,PFCTRM,APISTM
ISN 0013              READ* ,CONAXM,PCONPM,XNRMSM,PWPOM
ISN 0014              OCR=PCONPM/CONAXM
ISN 0015              IF (NHOLE.LE.0) GO TO 21
ISN 0017              WRITE(6,630)JSAMP,NHOLE,TDPTHM,BDPTHM,SHGHTM,SVOLM,
                     &SAREAM,CLOADM,PFCTRM,APISTM,RDILOM
ISN 0018              GO TO 9
ISN 0019           21 WRITE(6,631) JSAMP,SHGHTM,SVOLM,
                     1SAREAM,CLOADM,PFCTRM,APISTM,RDILOM
ISN 0020            9 I=0
ISN 0021              READ* ,M
ISN 0022              IF(M)1,1,10
ISN 0023           10 READ* ,JDATES,JDATEE
ISN 0024              WRITE(6,165)JDATES,JDATEE
ISN 0025              WRITE(6,64)
ISN 0026              WRITE(6,65)
ISN 0027              WRITE(6,69)
ISN 0028              WRITE(6,70)
ISN 0029              WRITE(6,710)
ISN 0030              WRITE(6,720)
               C
               C
               C      INPUT DATA FROM SHEAR TEST
               C     ==========================
----------------------------------------------------------------------------------------------------------

               C
               C
ISN 0031            4 READ* ,JTIME,RDIAL,PRING,PWP,CELLPR ,JPT
ISN 0032              IF (JTIME)6,5,5
ISN 0033            5 PWPRM=PWP
ISN 0034              IF (PWPRM)8,7,7
ISN 0035            7 I=I+1
               C
               C
               C      STRESS - STRAIN CALCULATION
               C     ===========================
               C
               C      NOTE:
               C
               C      (1) IF ( PWP ) IS NEGATIVE --- RELAXATION TEST
               C
               C      (3) IF ( PWP ) IS POSITIVE --- CONSOLIDATED UNDRAINED TRIAXIAL TES
               C
               C
ISN 0036              STRAIN(I)=(RDILOM-RDIAL)/(1000.*SHGHTM)*AA
ISN 0037              PCSTR=STRAIN(I)*100
ISN 0038              PCSTRN(I)= PCSTR
ISN 0039              JPTX(I)=JPT
ISN 0040              AREAM=SAREAM/(1.-STRAIN(I))
ISN 0041              F=1-APISTM/AREAM
ISN 0042              X=F*CELLPR
ISN 0043              XLOAD=PRING*PFCTRM+CLOADM
ISN 0044              Y=XLOAD/AREAM*10
ISN 0045              STRESM=X+Y
ISN 0046              EFSTRM=STRESM-PWPRM
ISN 0047              ECELPM=CELLPR-PWPRM
ISN 0048              DVSTRM(I)=(STRESM-CELLPR)
ISN 0049              HDVSTR=DVSTRM(I)/2
ISN 0050              OCTSTM(I)=(EFSTRM+2*ECELPM)/3
ISN 0051              RATIO=EFSTRM/ECELPM
               C
               C
               C      NORMALIZATION OF STRESSES
               C     =========================
               C
               C
ISN 0052              DEVSNM(I)=DVSTRM(I)/XNRMSM
ISN 0053              HDVSTN(I)=HDVSTR/XNRMSM
ISN 0054              OCTSNM(I)=OCTSTM(I)/XNRMSM
ISN 0055              DLTAUM=PWPRM-PWPOM
ISN 0056              DLTUNM(I)=DLTAUM/XNRMSM
ISN 0057              EFSRTO(I)=RATIO
ISN 0058              IF ( I.EQ.1 ) GO TO 106
ISN 0060              GO TO 107
ISN 0061          106 DEVSNO=DEVSNM(1)
ISN 0062              GO TO 108
ISN 0063          107 A(I)=DLTUNM(I)/(DEVSNM(I)-DEVSNO)
               C
               C
               C      PRINT CALCULATED RESULTS
               C     ========================
               C
               C
ISN 0064          108 WRITE(6,980)JPT,JTIME,RDIAL,PRING,PWPRM,PCSTR,
                     1EFSTRM,ECELPM,HDVSTR,DVSTRM(I),OCTSTM(I),RATIO,A(I)
ISN 0065              GO TO 4
ISN 0066            8 WRITE(6,81)JPT    ,JTIME,RDIAL,PRING
ISN 0067              GO TO 4
ISN 0068            6 READ* ,B
ISN 0069              IF (B) 13,13,1
ISN 0070           13 WRITE(6,99)
```

```
ISN 0071                IF (NHOLE.LE.0) GO TO 22
ISN 0073                WRITE(6,163)JSAMP,NHOLE,TDPTHM,BDPTHM,CONAXM,PCONPM,
                       1XNRMSM
ISN 0074                GO TO 26
ISN 0075             22 WRITE(6,60)
ISN 0076                WRITE(6,61)
ISN 0077                WRITE(6,164)JSAMP,CONAXM,PCONPM,XNRMSM
ISN 0078             26 WRITE(6,285)JDATES,JDATEE
ISN 0079                WRITE(6,860)
ISN 0080                DO 50 I=1,M
ISN-0081                WRITE(6,82)JPTX(I),PCSTRN(I),HDVSTN(I),EFSRTO(I),OCTSNM(I),
                       1DLTUNM(I)
ISN 0082             50 CONTINUE
                  C
                  C
                  C
                  C     *************************************
                  C     *   PHASE 2 : PLOT THE REDUCED DATA   *
                  C     *************************************
                  C
                  C
                  C     NOM. HALF DEV. STRESS VS. AXIAL STRAIN
                  C     ==================================
                  C
                  C
                  C
ISN 0083                CALL PLOTS(IBUF,4000)
ISN 0084                CALL PLOT(0.0,-5.0,-3)
ISN 0085                CALL PLOT(0.0,6.5,-3)
ISN 0086                PCSTRN(M+1)=0.0
ISN 0087                PCSTRN(M+2)=1.5
ISN 0088                HDVSTN(M+1)=0.0
ISN 0089                HDVSTN(M+2)=0.1
ISN 0090                CALL FACTOR(0.5)
ISN 0091                CALL AXIS(0.0,0.0,16HAXIAL STRAIN (%),-16,12.0,0.0,
                       &PCSTRN(M+1),PCSTRN(M+2))
ISN 0092                CALL AXIS(0.0,0.0,22HNOM. HALF DEV. STRESS ,22,7.0,90.0,
                       &HDVSTN(M+1),HDVSTN(M+2))
ISN 0093                CALL LINE(PCSTRN,HDVSTN,M,1,-1,1)
ISN 0094                CALL SYMBOL(5.4,7.4,0.28,4HT704,0.0,4)
ISN 0095                CALL PLOT(11.9,1.0,3)
ISN 0096                CALL PLOT(12.0,1.0,2)
ISN 0097                CALL PLOT(11.9,2.0,3)
ISN 0098                CALL PLOT(12.0,2.0,2)
ISN 0099                CALL PLOT(11.9,3.0,3)
ISN 0100                CALL PLOT(12.0,3.0,2)
ISN 0101                CALL PLOT(11.9,4.0,3)
ISN 0102                CALL PLOT(12.0,4.0,2)
ISN 0103                CALL PLOT(11.9,5.0,3)
ISN 0104                CALL PLOT(12.0,5.0,2)
ISN 0105                CALL PLOT(11.9,6.0,3)
ISN 0106                CALL PLOT(12.0,6.0,2)
ISN 0107                CALL PLOT(11.0,6.9,3)
ISN 0108                CALL PLOT(11.0,7.0,2)
ISN 0109                CALL PLOT(10.0,6.9,3)
ISN 0110                CALL PLOT(10.0,7.0,2)
ISN 0111                CALL PLOT(9.0,6.9,3)
ISN 0112                CALL PLOT(9.0,7.0,2)
ISN 0113                CALL PLOT(8.0,6.9,3)
ISN 0114                CALL PLOT(8.0,7.0,2)
ISN 0115                CALL PLOT(7.0,6.9,3)
ISN 0116                CALL PLOT(7.0,7.0,2)
ISN 0117                CALL PLOT(6.0,6.9,3)
ISN 0118                CALL PLOT(6.0,7.0,2)
ISN 0119                CALL PLOT(5.0,6.9,3)
ISN 0120                CALL PLOT(5.0,7.0,2)
ISN 0121                CALL PLOT(4.0,6.9,3)
-----------------------------------------------------------------------------------------------------------
ISN 0122                CALL PLOT(4.0,7.0,2)
ISN 0123                CALL PLOT(3.0,6.9,3)
ISN 0124                CALL PLOT(3.0,7.0,2)
ISN 0125                CALL PLOT(2.0,6.9,3)
ISN 0126                CALL PLOT(2.0,7.0,2)
ISN 0127                CALL PLOT(1.0,6.9,3)
ISN 0128                CALL PLOT(1.0,7.0,2)
ISN 0129                CALL PLOT(0.0,7.0,3)
ISN 0130                CALL PLOT(12.0,7.0,2)
ISN 0131                CALL PLOT(12.0,0.0,2)
                  C
                  C
                  C     EFF. STRESS RATIO VS. AXIAL STRAIN
                  C     ==============================
                  C
                  C
ISN 0132                CALL PLOT(0.0,-5.0,-3)
ISN 0133                EFSRTO(M+1)=1.0
ISN 0134                EFSRTO(M+2)=1.0
ISN 0135                CALL AXIS(0.0,0.0,16HAXIAL STRAIN (%),-16,12.0,0.0,
                       &PCSTRN(M+1),PCSTRN(M+2))
ISN 0136                CALL AXIS(0.0,0.0,22HEFFECTIVE STRESS RATIO,22,4.0,90.0,
                       &EFSRTO(M+1),EFSRTO(M+2))
ISN 0137                CALL LINE(PCSTRN,EFSRTO,M,1,-1,1)
ISN 0138                CALL PLOT(0.0,4.0,3)
ISN 0139                CALL PLOT(12.0,4.0,2)
ISN 0140                CALL PLOT(12.0,0.0,2)
ISN 0141                CALL PLOT(11.9,1.0,3)
ISN 0142                CALL PLOT(12.0,1.0,2)
ISN 0143                CALL PLOT(11.9,2.0,3)
ISN 0144                CALL PLOT(12.0,2.0,2)
ISN 0145                CALL PLOT(11.9,3.0,3)
ISN 0146                CALL PLOT(12.0,3.0,2)
ISN 0147                CALL PLOT(11.0,3.9,3)
ISN 0148                CALL PLOT(11.0,4.0,2)
ISN 0149                CALL PLOT(10.0,3.9,3)
ISN 0150                CALL PLOT(10.0,4.0,2)
ISN 0151                CALL PLOT(9.0,3.9,3)
ISN 0152                CALL PLOT(9.0,4.0,2)
ISN 0153                CALL PLOT(8.0,3.9,3)
ISN 0154                CALL PLOT(8.0,4.0,2)
ISN 0155                CALL PLOT(7.0,3.9,3)
ISN 0156                CALL PLOT(7.0,4.0,2)
ISN 0157                CALL PLOT(6.0,3.9,3)
ISN 0158                CALL PLOT(6.0,4.0,2)
ISN 0159                CALL PLOT(5.0,3.9,3)
ISN 0160                CALL PLOT(5.0,4.0,2)
ISN 0161                CALL PLOT(4.0,3.9,3)
ISN 0162                CALL PLOT(4.0,4.0,2)
ISN 0163                CALL PLOT(3.0,3.9,3)
ISN 0164                CALL PLOT(3.0,4.0,2)
ISN 0165                CALL PLOT(2.0,3.9,3)
ISN 0166                CALL PLOT(2.0,4.0,2)
ISN 0167                CALL PLOT(1.0,3.9,3)
ISN 0168                CALL PLOT(1.0,4.0,2)
                  C
                  C
                  C
                  C     PWP CHANGE VS. AXIAL STRAIN
                  C     ========================
                  C
                  C
                  C
ISN 0169                CALL PLOT(0.0,-5.0,-3)
ISN 0170                IF (OCR.GE.1.95) GO TO 51
ISN 0172                DLTUNM(M+1)=0.0
```

```
      GO TO 52
   51 DLTUNM(M+1)=-0.4
      CALL PLOT(0.0,2.0,3)
      CALL PLOT(12.0,2.0,2)
   52 DLTUNM(M+2)=0.2
      CALL AXIS(0.0,0.0,16HAXIAL STRAIN (%),-16,12.0,0.0,
     &PCSTRN(M+1),PCSTRN(M+2))
      CALL AXIS(0.0,0.0,15HNOM. PWP CHANGE,15,4.0,90.0,
     &DLTUNM(M+1),DLTUNM(M+2))
      CALL LINE(PCSTRN,DLTUNM,M,1,-1,1)
      CALL PLOT(0.0,4.0,3)
      CALL PLOT(12.0,4.0,2)
      CALL PLOT(12.0,0.0,2)
      CALL PLOT(11.9,1.0,3)
      CALL PLOT(12.0,1.0,2)
      CALL PLOT(11.9,2.0,3)
      CALL PLOT(12.0,2.0,2)
      CALL PLOT(11.9,3.0,3)
      CALL PLOT(12.0,3.0,2)
      CALL PLOT(11.0,3.9,3)
      CALL PLOT(11.0,4.0,2)
      CALL PLOT(10.0,3.9,3)
      CALL PLOT(10.0,4.0,2)
      CALL PLOT(9.0,3.9,3)
      CALL PLOT(9.0,4.0,2)
      CALL PLOT(8.0,3.9,3)
      CALL PLOT(8.0,4.0,2)
      CALL PLOT(7.0,3.9,3)
      CALL PLOT(7.0,4.0,2)
      CALL PLOT(6.0,3.9,3)
      CALL PLOT(6.0,4.0,2)
      CALL PLOT(5.0,3.9,3)
      CALL PLOT(5.0,4.0,2)
      CALL PLOT(4.0,3.9,3)
      CALL PLOT(4.0,4.0,2)
      CALL PLOT(3.0,3.9,3)
      CALL PLOT(3.0,4.0,2)
      CALL PLOT(2.0,3.9,3)
      CALL PLOT(2.0,4.0,2)
      CALL PLOT(1.0,3.9,3)
      CALL PLOT(1.0,4.0,2)
      CALL PLOT(24.0,0.0,-3)
C
C
C     EFF. MEAN PRINCIPAL STRESS VS. DEVIATOR STRESS
C     ============================================
C
C
      OCTSTM(M+1)=0.0
      OCTSTM(M+2)=15.0
      DVSTRM(M+1)=0.0
      DVSTRM(M+2)=15.0
      CALL AXIS(0.0,0.0,37HEFFECTIVE MEAN PRINCIPAL STRESS (KPA),
     *-37,11.0,0.0,OCTSTM(M+1),OCTSTM(M+2))
      CALL AXIS(0.0,0.0,21HDEVIATOR STRESS (KPA),21,9.0,90.0,
     *DVSTRM(M+1),DVSTRM(M+2))
      CALL LINE(OCTSTM,DVSTRM,M,1,-1,1)
      CALL SYMBOL(0.5,8.2,0.28,4HT704,0.0,4)
      CALL PLOT(0.0,9.0,3)
      CALL PLOT(11.0,9.0,2)
      CALL PLOT(11.0,0.0,2)
      CALL PLOT(10.9,1.0,3)
      CALL PLOT(11.0,1.0,2)
      CALL PLOT(10.9,2.0,3)
      CALL PLOT(11.0,2.0,2)
      CALL PLOT(10.9,3.0,3)
------------------------------------------------------------------------------------------------------------
      CALL PLOT(11.0,3.0,2)
      CALL PLOT(10.9,4.0,3)
      CALL PLOT(11.0,4.0,2)
      CALL PLOT(10.9,5.0,3)
      CALL PLOT(11.0,5.0,2)
      CALL PLOT(10.9,6.0,3)
      CALL PLOT(11.0,6.0,2)
      CALL PLOT(10.9,7.0,3)
      CALL PLOT(11.0,7.0,2)
      CALL PLOT(10.9,8.0,3)
      CALL PLOT(11.0,8.0,2)
      CALL PLOT(10.0,8.9,3)
      CALL PLOT(10.0,9.0,2)
      CALL PLOT(9.0,8.9,3)
      CALL PLOT(9.0,9.0,2)
      CALL PLOT(8.0,8.9,3)
      CALL PLOT(8.0,9.0,2)
      CALL PLOT(7.0,8.9,3)
      CALL PLOT(7.0,9.0,2)
      CALL PLOT(6.0,8.9,3)
      CALL PLOT(6.0,9.0,2)
      CALL PLOT(5.0,8.9,3)
      CALL PLOT(5.0,9.0,2)
      CALL PLOT(4.0,8.9,3)
      CALL PLOT(4.0,9.0,2)
      CALL PLOT(3.0,8.9,3)
      CALL PLOT(3.0,9.0,2)
      CALL PLOT(2.0,8.9,3)
      CALL PLOT(2.0,9.0,2)
      CALL PLOT(1.0,8.9,3)
      CALL PLOT(1.0,9.0,2)
      CALL PLOT(12.0,0.0,999)
C
C
C
C
      WRITE(6,99)
      GO TO 9
   60 FORMAT (1H1,10(/),T10,23H UNIVERSITY OF MANITOBA)
   61 FORMAT (T10,26H SOIL MECHANICS LABORATORY//)
   64 FORMAT(T10,37H CONSOLIDATED UNDRAINED TRIAXIAL TEST )
   65 FORMAT(T10,37H :::::::::::::::::::::::::::::::::::::    ///)
  163 FORMAT(T10,15H SAMPLE NO. = T,I4,5X,11H HOLE NO. = ,I4,5X,
     1  9H DEPTH = ,F6.2,11H METRES TO ,F6.2,8H METRES  //
     1    T10,37H CONSOLIDATION AXIAL STRESS         = ,F7.2,
     15H KPA /
     1   T10,37H PRECONSOLIDATION PRESSURE          =  ,F7.2,
     15H KPA /
     1   T10,37H NORMALIZING STRESS                 =  ,F7.2,
     15H KPA /)
  164 FORMAT(T10,15H SAMPLE NO. = T,I4,5X,'(REMOULDED SAMPLE)' //
     1    T10,37H CONSOLIDATION AXIAL STRESS         = ,F7.2,
     15H KPA /
     1   T10,37H PRECONSOLIDATION PRESSURE          =  ,F7.2,
     15H KPA /
     1   T10,37H NORMALIZING STRESS                 =  ,F7.2,
     15H KPA /)
  165 FORMAT(T10,28H SHEAR TEST RESULTS    START,  I10,5H      ,
     13HEND, I10           //)
  265 FORMAT(/  ,T10,39H NORMALIZED SHEAR TEST RESULTS    START,
     1I10,8H     END,I10         //)
   69 FORMAT(T10,46H  PT  TIME       DISPL   PRING   PORE    PER   ,
     162H  EFFECT   EFFECT   HALF     DEV     EFFECT  RATIO OF       A)
   70 FORMAT(T10,46H                  DIAL    DIAL    PRESS   CENT  ,
     157H  SIGMA1   SIGMA3   DEV     STRESS   OCT      EFF SIGMA1)
  980 FORMAT(T10,I4,2X,I4,3X,F7.1,4X,F5.1,2X,F6.1,2X,F5.2,4X,
```

```
                     1F5.1,4X,F5.1,4X,F5.1,4X,F5.1,4X,F5.1,5X,F6.3,4X,F7.2)
   ISN 0274         81 FORMAT(T10,I4,2X,I4,3X,F7.1,4X,F5.1,3X,15HRELAXATION TEST)
   ISN 0275         82 FORMAT(T10,I4,3X,F5.2,5X,F6.3,4X,F6.3,3X,F6.3,4X,F6.3)
   ISN 0276        631 FORMAT(T10,15H SAMPLE NO. = T,I4,5X,'(REMOULDED SAMPLE)' //
                     1T10,37H SAMPLE HEIGHT AFTER CONSOLIDATION = ,F7.3,
                     112H CENTIMETRES /
                     1        T10,37H SAMPLE VOLUME AFTER CONSOLIDATION =  ,F7.3,
                     118H CUBIC CENTIMETRES  /
                     1 T10,38H SAMPLE AREA AFTER CONSOLIDATION   =  ,F6.3,
                     1 19H SQUARE CENTIMETRES //
                     1T10,37H CONSTANT LOAD                     = ,F7.2,5H  N ./
                     1 T10,37H PROVING RING FACTOR               = ,F7.4,
                     1 9H  N ./DIV /
                     1 T10,37H PISTON AREA                       = ,F7.4,
                     119H SQUARE CENTIMETRES  //
                     1 T10,37H INITIAL DIAL READING              = ,F7.2,
                     110H DIVISIONS //)
   ISN 0277        630 FORMAT(T10,15H SAMPLE NO. = T,I4,5X,11H HOLE NO. = ,I4,5X,
                     1  9H DEPTH = ,F6.2,11H METRES TO ,F6.2,8H METRES  //
                     1T10,37H SAMPLE HEIGHT AFTER CONSOLIDATION = ,F7.3,
                     112H CENTIMETRES /
                     1        T10,37H SAMPLE VOLUME AFTER CONSOLIDATION =  ,F7.3,
                     118H CUBIC CENTIMETRES  /
                     1 T10,38H SAMPLE AREA AFTER CONSOLIDATION   =  ,F6.3,
                     1 19H SQUARE CENTIMETRES //
                     1T10,37H CONSTANT LOAD                     = ,F7.2,5H  N ./
                     1 T10,37H PROVING RING FACTOR               = ,F7.4,
                     1 9H  N ./DIV /
                     1 T10,37H PISTON AREA                       = ,F7.4,
                     119H SQUARE CENTIMETRES  //
                     1 T10,37H INITIAL DIAL READING              = ,F7.2,
                     110H DIVISIONS //)
   ISN 0278        710 FORMAT (T10,46H                 RDG     RDG     KPA      PCSTRN
                     1,57H  KPA      KPA       STRESS   KPA      STRESS   EFF SIFMA3)
   ISN 0279        720 FORMAT (T10,45H                                               ,
                     149H      .               KPA               KPA        /)
   ISN 0280        860 FORMAT(T10,
                     1       53H  PT    PER        NRMLZD    EFFECT   NRMLZD     NRMLZD  /
                     1   T10,53H        CENT       HALF      RATIO    OCT        CHANGE  /
                     1   T10,53H        PCSTRN     DEV       SIGMA1   STRESS     IN PWP  /
                     1   T10,53H                   STRESS    SIGMA3   KPA        KPA     /
                     1   T10,52H                   KPA                                /)
   ISN 0281         99 FORMAT(1H1,////)
   ISN 0282            END


                                                      /     MAIN /     SIZE OF PROGRAM 00784A HEXADECIMAL BYTES

       NAME    TAG   TYPE  ADD.         NAME    TAG   TYPE  ADD.         NAME    TAG   TYPE  ADD.         NAME    TAG   TYPE  ADD.
          A SF       R*4   0014C0          B S        R*4   001410          F SF       R*4   001414          I SF       I*4   001418
          M SFA      I*4   00141C          X SF       R*4   001420          Y SF       R*4   001424         AA SF       R*4   001428
         NS S        I*4   00142C        JPT SF       I*4   001430        LLL SF       I*4   001434        OCR S        R*4   001438
        PWP SF       R*4   00143C       AXIS SF  XF         000000       EXIT SF  XF         000000       IBUF SFA      I*4   001628
       JPTX SF       I*4   0054AC       LINE SF  XF         000000       PLOT SF  XF         000000      AREAM SF       R*4   001440
      JSAMP SF       I*4   001444      JTIME SF       I*4   001448      NHOLE SF       I*4   00144C      PCSTR SF       R*4   001450
      PLOTS SF  XF         000000      PRING SF       R*4   001454      PWPOM SF       R*4   001458      PWPRM SF       R*4   00145C
      RATIO SF       R*4   001460      RDIAL SF       R*4   001464      SVOLM SF       R*4   001468      XLOAD SF       R*4   00146C
     APISTM SF       R*4   001470     BDPTHM SF       R*4   001474     CELLPR SF       R*4   001478     CLOADM SF       R*4   00147C
     CONAXM SF       R*4   001480     DEVSNM SF       R*4   005614     DEVSNO SF       R*4   001484     DLTAUM SF       R*4   001488
     DLTUNM SFA      R*4   00577C     DVSTRM SFA      R*4   0058E4     ECELPM SF       R*4   00148C     EFSRTO SFA      R*4   005A4C
     EFSTRM SF       R*4   001490     FACTOR SF  XF         000000     HDVSTN SFA      R*4   005BB4     HDVSTR SF       R*4   001494
     IBCOM#  F  XF   I*4   000000     JDATEE SF       I*4   001498     JDATES SF       I*4   00149C     LDFIO#  F  XF   I*4   000000
     OCTSNM SF       R*4   005D1C     OCTSTM SFA      R*4   005E84     PCONPM SF       R*4   0014A0     PCSTRN SFA      R*4   005FEC
     PFCTRM SF       R*4   0014A4     RDILOM SF       R*4   0014A8     SAREAM SF       R*4   0014AC     SHGHTM SF       R*4   0014B0
     STRAIN SF       R*4   006154     STRESM SF       R*4   0014B4     SYMBOL SF  XF         000000     TDPTHM SF       R*4   0014B8
     XNRMSM SF       R*4   0014BC

-------------------------------------------------------------------------------------------------------------------------------------


  SOURCE STATEMENT LABELS

    LABEL  ISN  ADDR             LABEL  ISN  ADDR             LABEL  ISN  ADDR             LABEL  ISN  ADDR
        1    3  00638C                2    5  0063CC                3    6  0063D8               21   19  00655A
        9   20  0065B0               10   23  0065E0                4   31  0066A0                5   33  0066F0
        7   35  006700              106   61  0068FA              107   63  00690C              108   64  006950
        8   66  0069EE                6   68  006A2A               13   70  006A54               22   75  006AC6
       26   78  006B24               50   82  006BDC               51  174  00722E               52  177  007260

  COMPILER GENERATED LABELS

    LABEL  ISN  ADDR             LABEL  ISN  ADDR             LABEL  ISN  ADDR             LABEL  ISN  ADDR
   100000    1  00638C           100001   17  0064E8           100002   60  0068F4           100003   73  006A74
   100004   81  006B64           100005   83  006BF2           200001   96  006D4E           200002  112  006E2E
   200003  128  006F0E           200004  140  00704E           200005  156  00712E           100006  172  007214
   200006  189  00738A           200007  205  00746A           200008  219  0075B6           200009  234  007692
   200010  250  007772

  FORMAT STATEMENT LABELS

    LABEL  ISN  ADDR             LABEL  ISN  ADDR             LABEL  ISN  ADDR             LABEL  ISN  ADDR
       60  263  000028               61  264  00004C               64  265  00006E               65  266  000099
      163  267  0000C7              164  268  0001B7              165  269  000282              265  270  0002B6
       69  271  0002F4               70  272  000368              980  273  0003D7               81  274  000418
       82  275  00043F              631  276  00045E              630  277  000636              710  278  000833
      720  279  0008A2              860  280  000909               99  281  000A2C

*OPTIONS IN EFFECT*NAME(MAIN) NOOPTIMIZE LINECOUNT(54) SIZE(0256K) AUTODBL(NONE)

*OPTIONS IN EFFECT*SOURCE EBCDIC NOLIST NODECK OBJECT MAP NOFORMAT GOSTMT NOXREF NOALC NOANSF NOTERM IBM FLAG(I)

*STATISTICS*     SOURCE STATEMENTS =      281, PROGRAM SIZE =     30794, SUBPROGRAM NAME =  MAIN

*STATISTICS*  NO  DIAGNOSTICS GENERATED

****** END OF COMPILATION ******                                          84K BYTES OF CORE NOT USED
```

APPENDIX C

TABULATED LABORATORY TEST RESULTS

```
UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

SAMPLE NO. : T 702      (REMOULDED SAMPLE)
INITIAL MOISTURE CONTENT           :   52.1 PERCENT
SPECIFIC GRAVITY OF SOIL           :  2.73
INITIAL VOID RATIO                 :   1.423
INITIAL HEIGHT OF SAMPLE           :  12.90 CM
INITIAL VOLUME OF SAMPLE           :  585.20 CC
EFFECTIVE PRINCIPAL STRESS RATIO   :  0.57
FINAL MOISTURE CONTENT             :   41.2 PERCENT

TX.  CONSOLIDATION    START      70983      END    200983
TRIAXIAL CONSOLIDATION TEST
:::::::::::::::::::::::::::


 PT  EFFECT    EFFECT   STRAIN1    VOLUME   STRAIN3    EFFECT      Q        VOID        V       SHEAR
     SIGMA1    SIGMA3              STRAIN                P                  RATIO                STRAIN

  1   50.24     28.50     1.875     3.016     0.570     35.75     21.74     1.350     2.350     0.870
  2   57.87     32.90     2.426     3.973     0.773     41.22     24.97     1.326     2.326     1.102
  3   66.70     37.90     3.202     5.195     0.997     47.50     28.80     1.297     2.297     1.470
  4   76.80     43.70     4.093     6.494     1.200     54.73     33.10     1.265     2.265     1.929
  5   88.63     50.36     5.062     7.826     1.382     63.12     38.27     1.233     2.233     2.453
  6  101.87     58.00     6.142     9.211     1.534     72.62     43.87     1.199     2.199     3.072
  7  117.25     66.80     7.271    10.629     1.679     83.62     50.45     1.165     2.165     3.728
  8  134.90     76.80     8.465    12.073     1.804     96.17     58.10     1.130     2.130     4.441
  9  160.21     91.20    10.015    13.838     1.911    114.20     69.01     1.087     2.087     5.403
 10   79.90     45.60     9.188    12.432     1.622     57.03     34.30     1.121     2.121     5.044
 11   79.89     45.60     9.157    12.346     1.594     57.03     34.29     1.124     2.124     5.042
```

```
SUMMARY OF ESSENTIAL RESULTS STORED IN FILE


 PT  SIGMA1    SIGMA3    STRAIN1    STRAIN3      V

  1   50.24     28.50     1.875      0.570     2.350
  2   57.87     32.90     2.426      0.773     2.326
  3   66.70     37.90     3.202      0.997     2.297
  4   76.80     43.70     4.093      1.200     2.265
  5   88.63     50.36     5.062      1.382     2.233
  6  101.87     58.00     6.142      1.534     2.199
  7  117.25     66.80     7.271      1.679     2.165
  8  134.90     76.80     8.465      1.804     2.130
  9  160.21     91.20    10.015      1.911     2.087
 10   79.90     45.60     9.188      1.622     2.121
 11   79.89     45.60     9.157      1.594     2.124
```

```
UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

ENERGY CALCULATIONS

****  ENGINEERING STRAIN  ****

SAMPLE NO. : T 702      (REMOULDED SAMPLE)
TEST RESULTS     START     70983      END     200983

 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     50.2      28.5     21.7      35.7     1.875    0.570     3.016      0.0     0.0                0.0
                                                                                             0.423
  2     57.9      32.9     25.0      41.2     2.426    0.773     3.973      9.8     0.6                0.423
                                                                                             0.641
  3     66.7      37.9     28.8      47.5     3.202    0.997     5.195     21.2     1.5                1.063
                                                                                             0.806
  4     76.8      43.7     33.1      54.7     4.093    1.200     6.494     34.2     2.4                1.869
                                                                                             0.973
  5     88.6      50.4     38.3      63.1     5.062    1.382     7.826     49.3     3.4                2.842
                                                                                             1.193
  6    101.9      58.0     43.9      72.6     6.142    1.534     9.211     66.4     4.5                4.035
                                                                                             1.418
  7    117.2      66.8     50.4      83.6     7.271    1.679    10.629     86.2     5.6                5.453
                                                                                             1.685
  8    134.9      76.8     58.1      96.2     8.465    1.804    12.073    108.8     6.8                7.138
                                                                                             2.468
  9    160.2      91.2     69.0     114.2    10.015    1.911    13.838    141.3     8.4                9.606
                                                                                            -1.390
 10     79.9      45.6     34.3      57.0     9.188    1.622    12.432     38.3     7.5                8.216
                                                                                            -0.049
 11     79.8      45.6     34.3      57.0     9.157    1.594    12.346     38.3     7.4                8.167
```

```
UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

ENERGY CALCULATIONS

****    NATURAL STRAIN    ****

SAMPLE NO. : T 702      (REMOULDED SAMPLE)
TEST RESULTS     START     70983      END     200983

 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     50.2      28.5     21.7      35.7     1.893    0.585     3.062      0.0     0.0                0.0
                                                                                             0.436
  2     57.9      32.9     25.0      41.2     2.456    0.799     4.054      9.8     0.6                0.436
                                                                                             0.668
  3     66.7      37.9     28.8      47.5     3.254    1.040     5.334     21.2     1.5                1.104
                                                                                             0.849
  4     76.8      43.7     33.1      54.7     4.179    1.267     6.714     34.2     2.5                1.953
                                                                                             1.038
  5     88.6      50.4     38.3      63.1     5.195    1.477     8.149     49.3     3.5                2.990
                                                                                             1.290
  6    101.9      58.0     43.9      72.6     6.338    1.662     9.662     66.4     4.7                4.280
                                                                                             1.553
  7    117.2      66.8     50.4      83.6     7.549    1.844    11.237     86.2     5.9                5.833
                                                                                             1.873
  8    134.9      76.8     58.1      96.2     8.845    2.010    12.866    108.8     7.2                7.706
                                                                                             2.789
  9    160.2      91.2     69.0     114.2    10.553    2.170    14.894    141.3     8.9               10.495
                                                                                            -1.580
 10     79.9      45.6     34.3      57.0     9.637    1.819    13.275     38.3     7.9                8.915
                                                                                            -0.056
 11     79.9      45.6     34.3      57.0     9.604    1.787    13.177     38.3     7.9                8.859
```

```
UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

SAMPLE NO. : T 702      (REMOULDED SAMPLE)

SAMPLE HEIGHT AFTER CONSOLIDATION :  11.719 CENTIMETRES
SAMPLE VOLUME AFTER CONSOLIDATION : 512.950 CUBIC CENTIMETRES
SAMPLE AREA AFTER CONSOLIDATION   :  43.772 SQUARE CENTIMETRES

CONSTANT LOAD                     :   16.54  N .
PROVING RING FACTOR               :  1.2365  N ./DIV
PISTON AREA                       :  5.0700 SQUARE CENTIMETRES

INITIAL DIAL READING              : 1500.00 DIVISIONS


SHEAR TEST RESULTS    START    220983     END    240983


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     PCSTRN  KPA      KPA     STRESS  KPA     STRESS  EFF SIFMA3
                                                               KPA             KPA

  1   951    1500.0   331.7   500.0   0.0      80.8    46.6    17.1    34.2    58.0    1.733      0.0
  2  1000    1498.5   345.1   489.0   0.01     94.8    56.7    19.0    38.1    69.4    1.671    -2.83
  3  1015    1493.0   378.2   490.1   0.06    103.0    55.6    23.7    47.4    71.4    1.852    -0.75
  4  1030    1481.8   407.5   492.0   0.16    109.3    53.7    27.8    55.6    72.2    2.035    -0.37
  5  1045    1478.7   430.5   493.9   0.18    113.7    51.6    31.0    62.1    72.3    2.203    -0.22
  6  1100    1469.5   450.0   495.1   0.26    117.8    50.3    33.8    67.5    72.8    2.343    -0.15
  7  1115    1459.9   466.0   496.7   0.34    120.7    48.7    36.0    72.0    72.7    2.478    -0.09
  8  1130    1448.5   480.0   497.7   0.44    123.5    47.6    37.9    75.9    72.9    2.594    -0.06
  9  1145    1437.8   490.5   497.5   0.53    126.5    47.7    39.4    78.8    74.0    2.651    -0.06
 10  1159    1426.8   498.5   497.2   0.62    126.3    45.0    40.6    81.3    72.1    2.806    -0.06
 11  1216    1412.3   505.6   497.7   0.75    130.2    47.4    41.4    82.8    75.0    2.748    -0.05
 12  1230    1400.2   510.0   497.4   0.85    131.9    47.9    42.0    84.0    75.9    2.753    -0.05
 13  1245    1387.0   514.0   497.1   0.96    133.2    48.2    42.5    85.0    76.5    2.763    -0.06
 14  1300    1373.5   517.0   496.3   1.08    135.1    49.4    42.8    85.7    78.0    2.734    -0.07
 15  1315    1360.2   519.5   497.0   1.19    135.0    48.7    43.1    86.3    77.5    2.772    -0.06
 16  1330    1346.2   521.4   497.2   1.31    135.4    48.7    43.3    86.7    77.6    2.780    -0.05
 17  1345    1332.0   522.5   498.2   1.43    134.3    47.4    43.5    86.9    76.4    2.834    -0.03
 18  1400    1319.0   523.8   498.1   1.54    134.6    47.4    43.6    87.2    76.5    2.840    -0.04
 19  1415    1305.2   524.7   498.4   1.66    134.4    47.1    43.7    87.3    76.2    2.854    -0.03
 20  1430    1292.0   524.8   498.8   1.77    134.1    46.8    43.6    87.3    75.9    2.864    -0.02
 21  1445    1277.5   525.5   499.1   1.90    133.8    46.5    43.7    87.3    75.6    2.878    -0.02
 22  1500    1263.7   525.8   499.0   2.02    133.8    46.5    43.7    87.3    75.6    2.878    -0.02
 23  1515    1248.6   525.9   499.6   2.15    132.9    45.6    43.6    87.3    74.7    2.914    -0.01
 24  1530    1235.0   525.8   499.7   2.26    132.6    45.4    43.6    87.2    74.5    2.920    -0.01
 25  1545    1220.8   526.0   500.3   2.38    132.2    45.1    43.5    87.1    74.1    2.931     0.01
 26  1600    1206.2   525.3   500.5   2.51    131.6    44.8    43.4    86.8    73.7    2.937     0.01

---------------------------------------------------------------------------------------------------------

 27  1615    1191.2   525.8   499.5   2.64    132.6    45.8    43.4    86.8    74.7    2.895    -0.01
 28  1645    1163.9   525.4   500.8   2.87    131.1    44.6    43.2    86.5    73.4    2.939     0.02
 29  1715    1135.0   524.5   501.6   3.11    129.8    43.8    43.0    86.0    72.5    2.964     0.03
 30  1717    1132.9   523.5   RELAXATION TEST
 31  1721    1131.5   517.8   RELAXATION TEST
 32  1728    1130.0   511.0   RELAXATION TEST
 33  1736    1128.8   505.6   RELAXATION TEST
 34  1746    1127.5   501.3   RELAXATION TEST
 35  1800    1126.3   497.2   RELAXATION TEST
 36  1824    1125.2   492.2   RELAXATION TEST
 37  2000    1122.8   483.2   RELAXATION TEST
 38  2100    1120.7   477.5   RELAXATION TEST
 39   832    1114.7   455.6   RELAXATION TEST
 40   835    1114.6   455.2   492.7   3.29    121.1    54.4    33.4    66.7    76.6    2.227    -0.22
 41   845    1111.2   481.2   489.3   3.32    130.2    56.2    37.0    74.0    80.9    2.317    -0.27
 42   900    1105.5   509.6   492.5   3.37    134.5    52.8    40.9    81.7    80.0    2.548    -0.16
 43   915    1096.6   530.1   494.5   3.44    138.0    50.7    43.6    87.3    79.8    2.721    -0.10
 44   930    1085.2   542.1   495.6   3.54    140.0    49.5    45.2    90.5    79.7    2.827    -0.08
 45   945    1073.0   547.0   496.7   3.64    140.5    48.9    45.8    91.6    79.4    2.874    -0.06
 46  1000    1059.3   549.0   496.9   3.76    140.7    48.6    46.0    92.1    79.3    2.895    -0.05
 47  1015    1044.7   548.8   497.0   3.89    140.2    48.3    46.0    91.9    78.9    2.903    -0.05
 48  1030    1031.5   548.0   497.2   4.00    139.7    48.1    45.8    91.6    78.6    2.904    -0.05
 49  1147     956.8   541.3   498.6   4.64    135.4    46.2    44.6    89.2    75.9    2.932    -0.03
 50  1230     916.0   541.1   500.1   4.98    134.3    45.5    44.4    88.8    75.1    2.951     0.00
 51  1300     887.0   540.0   500.9   5.23    132.9    44.6    44.1    88.3    74.0    2.979     0.02
 52  1330     858.9   538.4   501.3   5.47    131.8    44.2    43.8    87.6    73.4    2.982     0.02
 53  1400     830.8   537.7   501.3   5.71    131.1    43.9    43.6    87.2    73.0    2.987     0.02
 54  1500     773.0   536.5   502.0   6.20    129.5    43.0    43.2    86.5    71.8    3.011     0.04
 55  1600     716.3   535.8   502.7   6.69    128.1    42.2    42.9    85.9    70.8    3.035     0.05
 56  1630     689.0   537.5   500.8   6.92    131.1    45.1    43.0    86.0    73.8    2.907     0.02
 57  2030     462.0   539.4   504.4   8.86    126.2    41.5    42.3    84.7    69.7    3.041     0.09
 58   931     405.6   540.5   504.0   9.34    126.6    42.1    42.3    84.5    70.3    3.007     0.08
```

```
UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

SAMPLE NO. : T 702     (REMOULDED SAMPLE)

CONSOLIDATION AXIAL STRESS         :   79.89 KPA
PRECONSOLIDATION PRESSURE          :  160.21 KPA
NORMALIZING STRESS                 :  160.21 KPA

NORMALIZED SHEAR TEST RESULTS    START    220983     END     240983

 PT     PER       NRMLZD    EFFECT   NRMLZD    NRMLZD
        CENT      HALF      RATIO    OCT       CHANGE
        PCSTRN    DEV       SIGMA1   STRESS    IN PWP
                  STRESS    SIGMA3   KPA       KPA
                  KPA

  1     0.0       0.107     1.733    0.362      0.0
  2     0.01      0.119     1.671    0.433     -0.069
  3     0.06      0.148     1.852    0.446     -0.062
  4     0.16      0.174     2.035    0.451     -0.050
  5     0.18      0.194     2.203    0.451     -0.038
  6     0.26      0.211     2.343    0.455     -0.031
  7     0.34      0.225     2.478    0.454     -0.021
  8     0.44      0.237     2.594    0.455     -0.014
  9     0.53      0.246     2.651    0.462     -0.016
 10     0.62      0.254     2.806    0.450     -0.017
 11     0.75      0.259     2.748    0.468     -0.014
 12     0.85      0.262     2.753    0.474     -0.016
 13     0.96      0.265     2.763    0.478     -0.018
 14     1.08      0.267     2.734    0.487     -0.023
 15     1.19      0.269     2.772    0.483     -0.019
 16     1.31      0.271     2.780    0.484     -0.017
 17     1.43      0.271     2.834    0.477     -0.011
 18     1.54      0.272     2.840    0.477     -0.012
 19     1.66      0.273     2.854    0.476     -0.010
 20     1.77      0.272     2.864    0.474     -0.007
 21     1.90      0.273     2.878    0.472     -0.006
 22     2.02      0.273     2.878    0.472     -0.006
 23     2.15      0.272     2.914    0.466     -0.002
 24     2.26      0.272     2.920    0.465     -0.002
 25     2.38      0.272     2.931    0.463      0.002
 26     2.51      0.271     2.937    0.460      0.003
 27     2.64      0.271     2.895    0.466     -0.003
 28     2.87      0.270     2.939    0.458      0.005
 29     3.11      0.268     2.964    0.452      0.010
 40     3.29      0.208     2.227    0.478     -0.046
 41     3.32      0.231     2.317    0.505     -0.067
 42     3.37      0.255     2.548    0.500     -0.047
 43     3.44      0.272     2.721    0.498     -0.034
 44     3.54      0.282     2.827    0.497     -0.027
 45     3.64      0.286     2.874    0.496     -0.021
 46     3.76      0.287     2.895    0.495     -0.019
----------------------------------------------------------------------------------------------------------------------------

 47     3.89      0.287     2.903    0.493     -0.019
 48     4.00      0.286     2.904    0.491     -0.017
 49     4.64      0.279     2.932    0.474     -0.009
 50     4.98      0.277     2.951    0.469      0.001
 51     5.23      0.275     2.979    0.462      0.006
 52     5.47      0.273     2.982    0.458      0.008
 53     5.71      0.272     2.987    0.456      0.008
 54     6.20      0.270     3.011    0.448      0.012
 55     6.69      0.268     3.035    0.442      0.017
 56     6.92      0.268     2.907    0.460      0.005
 57     8.86      0.264     3.041    0.435      0.027
 58     9.34      0.264     3.007    0.439      0.025
```

```
UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY


SAMPLE NO. : T 704      (REMOULDED SAMPLE)
INITIAL MOISTURE CONTENT           :    51.5 PERCENT
SPECIFIC GRAVITY OF SOIL           :  2.73
INITIAL VOID RATIO                 :    1.405
INITIAL HEIGHT OF SAMPLE           :  12.87 CM
INITIAL VOLUME OF SAMPLE           :  583.97 CC
EFFECTIVE PRINCIPAL STRESS RATIO   :  1.00
FINAL MOISTURE CONTENT             :    40.7 PERCENT


TX.  CONSOLIDATION    START    280983     END     71083
TRIAXIAL CONSOLIDATION TEST
:::::::::::::::::::::::::::




 PT   EFFECT    EFFECT   STRAIN1    VOLUME   STRAIN3    EFFECT        Q        VOID         V        SHEAR
      SIGMA1    SIGMA3              STRAIN               P                    RATIO                  STRAIN


  1    50.22     28.40     1.913     2.791     0.439     35.67     21.82     1.338     2.338     0.983
  2    57.89     32.70     2.448     3.776     0.664     41.10     25.19     1.314     2.314     1.189
  3    66.48     36.86     3.201     4.906     0.852     46.73     29.62     1.287     2.287     1.566
  4    76.53     42.35     4.157     6.130     0.987     53.74     34.18     1.257     2.257     2.113
  5    88.08     48.67     5.218     7.449     1.116     61.81     39.41     1.226     2.226     2.735
  6   101.39     55.70     6.480     8.853     1.187     70.93     45.69     1.192     2.192     3.529
  7   116.78     64.00     7.807    10.394     1.294     81.59     52.78     1.155     2.155     4.343
  8   134.46     73.60     9.100    11.824     1.362     93.89     60.86     1.120     2.120     5.159
  9   160.04     87.50    10.862    13.597     1.367    111.68     72.54     1.078     2.078     6.330
 10    79.80     43.80    10.021    12.192     1.086     55.80     36.00     1.112     2.112     5.957
 11    79.76     43.80    10.117    12.184     1.034     55.79     35.96     1.112     2.112     6.055
 12    75.20     46.20    10.096    12.184     1.044     55.87     29.00     1.112     2.112     6.035
 13    70.10     48.10    10.082    12.184     1.051     55.43     22.00     1.112     2.112     6.020
 14    66.00     51.00    10.050    12.184     1.067     56.00     15.00     1.112     2.112     5.988
 15    62.00     54.00    10.012    12.184     1.086     56.67      8.00     1.112     2.112     5.950
 16    57.00     57.00     9.899    12.184     1.142     57.00      0.0      1.112     2.112     5.838
 17    55.80     55.80     9.852    12.184     1.166     55.80      0.0      1.112     2.112     5.790
 18    55.20     55.20     9.779    12.184     1.202     55.20      0.0      1.112     2.112     5.718
 19    55.20     55.20     9.650    12.184     1.267     55.20      0.0      1.112     2.112     5.588
 20    55.60     55.60     9.415    12.184     1.384     55.60      0.0      1.112     2.112     5.354
 21    56.10     56.10     9.373    12.184     1.405     56.10      0.0      1.112     2.112     5.312
 22    55.30     55.30     9.689    12.184     1.247     55.30      0.0      1.112     2.112     5.628
 23    55.70     55.70     9.687    12.184     1.248     55.70      0.0      1.112     2.112     5.626
 24    55.70     55.70     9.684    12.184     1.250     55.70      0.0      1.112     2.112     5.622
 25    55.80     55.80     9.671    12.184     1.256     55.80      0.0      1.112     2.112     5.610
```

```
SUMMARY OF ESSENTIAL RESULTS STORED IN FILE



 PT   SIGMA1    SIGMA3    STRAIN1    STRAIN3       V


  1    50.22     28.40     1.913     0.439     2.338
  2    57.89     32.70     2.448     0.664     2.314
  3    66.48     36.86     3.201     0.852     2.287
  4    76.53     42.35     4.157     0.987     2.257
  5    88.08     48.67     5.218     1.116     2.226
  6   101.39     55.70     6.480     1.187     2.192
  7   116.78     64.00     7.807     1.294     2.155
  8   134.46     73.60     9.100     1.362     2.120
  9   160.04     87.50    10.862     1.367     2.078
 10    79.80     43.80    10.021     1.086     2.112
 11    79.76     43.80    10.117     1.034     2.112
 12    75.20     46.20    10.096     1.044     2.112
 13    70.10     48.10    10.082     1.051     2.112
 14    66.00     51.00    10.050     1.067     2.112
 15    62.00     54.00    10.012     1.086     2.112
 16    57.00     57.00     9.899     1.142     2.112
 17    55.80     55.80     9.852     1.166     2.112
 18    55.20     55.20     9.779     1.202     2.112
 19    55.20     55.20     9.650     1.267     2.112
 20    55.60     55.60     9.415     1.384     2.112
 21    56.10     56.10     9.373     1.405     2.112
 22    55.30     55.30     9.689     1.247     2.112
 23    55.70     55.70     9.687     1.248     2.112
 24    55.70     55.70     9.684     1.250     2.112
 25    55.80     55.80     9.671     1.256     2.112
```

```
UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

ENERGY CALCULATIONS

****  ENGINEERING STRAIN  ****

SAMPLE NO. : T 704      (REMOULDED SAMPLE)
TEST RESULTS     START    280983      END     71083


 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     50.2      28.4      21.8      35.7      1.913     0.439      2.791      0.0     0.0               0.0
                                                                                               0.426
  2     57.9      32.7      25.2      41.1      2.448     0.664      3.776      9.8     0.6               0.426
                                                                                               0.600
  3     66.5      36.9      29.6      46.7      3.201     0.852      4.906     20.2     1.4               1.026
                                                                                               0.790
  4     76.5      42.4      34.2      53.7      4.157     0.987      6.130     32.9     2.4               1.816
                                                                                               0.990
  5     88.1      48.7      39.4      61.8      5.218     1.116      7.449     47.5     3.4               2.806
                                                                                               1.270
  6    101.4      55.7      45.7      70.9      6.480     1.187      8.853     64.1     4.7               4.076
                                                                                               1.576
  7    116.8      64.0      52.8      81.6      7.807     1.294     10.394     83.5     6.0               5.652
                                                                                               1.718
  8    134.5      73.6      60.9      93.9      9.100     1.362     11.824    105.7     7.3               7.370
                                                                                               2.603
  9    160.0      87.5      72.5     111.7     10.862     1.367     13.597    138.0     9.0               9.973
                                                                                              -1.379
 10     79.8      43.8      36.0      55.8     10.021     1.086     12.192     36.7     8.2               8.595
                                                                                               0.031
 11     79.8      43.8      36.0      55.8     10.117     1.034     12.184     36.7     8.2               8.626
                                                                                              -0.007
 12     75.2      46.2      29.0      55.9     10.096     1.044     12.184     35.5     8.2               8.619
                                                                                              -0.004
 13     70.1      48.1      22.0      55.4     10.082     1.051     12.184     34.2     8.2               8.615
                                                                                              -0.006
 14     66.0      51.0      15.0      56.0     10.050     1.067     12.184     35.6     8.2               8.609
                                                                                              -0.004
 15     62.0      54.0       8.0      56.7     10.012     1.086     12.184     38.1     8.2               8.605
                                                                                              -0.005
 16     57.0      57.0       0.0      57.0      9.899     1.142     12.184     41.0     8.0               8.600
                                                                                               0.0
 17     55.8      55.8       0.0      55.8      9.852     1.166     12.184     39.1     8.0               8.600
                                                                                              -0.000
 18     55.2      55.2       0.0      55.2      9.779     1.202     12.184     38.2     7.9               8.600
                                                                                               0.0
 19     55.2      55.2       0.0      55.2      9.650     1.267     12.184     38.2     7.8               8.600
--------------------------------------------------------------------------------------------------------------------------
                                                                                               0.0
 20     55.6      55.6       0.0      55.6      9.415     1.384     12.184     38.8     7.6               8.600
                                                                                               0.0
 21     56.1      56.1       0.0      56.1      9.373     1.405     12.184     39.6     7.6               8.600
                                                                                               0.0
 22     55.3      55.3       0.0      55.3      9.689     1.247     12.184     38.4     7.9               8.600
                                                                                               0.0
 23     55.7      55.7       0.0      55.7      9.687     1.248     12.184     39.0     7.9               8.600
                                                                                               0.0
 24     55.7      55.7       0.0      55.7      9.684     1.250     12.184     39.0     7.9               8.600
                                                                                               0.000
 25     55.8      55.8       0.0      55.8      9.671     1.256     12.184     39.1     7.8               8.600
```

```
UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

ENERGY CALCULATIONS

****    NATURAL STRAIN    ****

SAMPLE NO. = T 704      (REMOULDED SAMPLE)
TEST RESULTS     START     280983      END      71083


 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      50.2       28.4      21.8       35.7       1.931    0.450      2.831       0.0     0.0                   0.0
                                                                                                     0.439
  2      57.9       32.7      25.2       41.1       2.478    0.685      3.849       9.8     0.6                   0.439
                                                                                                     0.623
  3      66.5       36.9      29.6       46.7       3.254    0.888      5.030      20.2     1.5                   1.063
                                                                                                     0.830
  4      76.5       42.4      34.2       53.7       4.246    1.040      6.326      32.9     2.5                   1.883
                                                                                                     1.053
  5      88.1       48.7      39.4       61.8       5.359    1.191      7.741      47.5     3.6                   2.946
                                                                                                     1.368
  6     101.4       55.7      45.7       70.9       6.700    1.285      9.270      64.1     4.9                   4.314
                                                                                                     1.724
  7     116.8       64.0      52.8       81.6       8.129    1.423     10.875      83.5     6.3                   6.039
                                                                                                     1.909
  8     134.5       73.6      60.9       93.9       9.541    1.521     12.583     105.7     7.8                   7.948
                                                                                                     2.941
  9     160.0       87.5      72.5      111.7      11.499    1.558     14.614     138.0     9.7                  10.889
                                                                                                    -1.568
 10      79.8       43.8      36.0       55.8      10.559    1.221     13.002      36.7     8.7                   9.321
                                                                                                     0.034
 11      79.8       43.8      36.0       55.8      10.665    1.163     12.992      36.7     8.8                   9.355
                                                                                                    -0.007
 12      75.2       46.2      29.0       55.9      10.643    1.175     12.992      35.5     8.8                   9.347
                                                                                                    -0.004
 13      70.1       48.1      22.0       55.4      10.627    1.183     12.992      34.2     8.8                   9.343
                                                                                                    -0.007
 14      66.0       51.0      15.0       56.0      10.591    1.200     12.992      35.6     8.7                   9.337
                                                                                                    -0.005
 15      62.0       54.0       8.0       56.7      10.549    1.222     12.992      38.1     8.7                   9.332
                                                                                                    -0.005
 16      57.0       57.0       0.0       57.0      10.424    1.284     12.992      41.0     8.6                   9.327
                                                                                                    -0.000
 17      55.8       55.8       0.0       55.8      10.371    1.310     12.992      39.1     8.5                   9.327
                                                                                                    -0.000
 18      55.2       55.2       0.0       55.2      10.291    1.351     12.992      38.2     8.5                   9.327
                                                                                                    -0.000
 19      55.2       55.2       0.0       55.2      10.147    1.422     12.992      38.2     8.3                   9.327

------------------------------------------------------------------------------------------------------------------------------

                                                                                                    -0.000
 20      55.6       55.6       0.0       55.6       9.888    1.552     12.992      38.8     8.1                   9.327
                                                                                                    -0.000
 21      56.1       56.1       0.0       56.1       9.842    1.575     12.992      39.6     8.1                   9.327
                                                                                                    -0.000
 22      55.3       55.3       0.0       55.3      10.191    1.400     12.992      38.4     8.4                   9.327
                                                                                                    -0.000
 23      55.7       55.7       0.0       55.7      10.189    1.402     12.992      39.0     8.4                   9.327
                                                                                                    -0.000
 24      55.7       55.7       0.0       55.7      10.185    1.403     12.992      39.0     8.4                   9.327
                                                                                                    -0.000
 25      55.8       55.8       0.0       55.8      10.171    1.410     12.992      39.1     8.4                   9.327
```

```
UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

SAMPLE NO. = T 704      (REMOULDED SAMPLE)

SAMPLE HEIGHT AFTER CONSOLIDATION =  11.569 CENTIMETRES
SAMPLE VOLUME AFTER CONSOLIDATION = 511.970 CUBIC CENTIMETRES
SAMPLE AREA AFTER CONSOLIDATION   =  44.252 SQUARE CENTIMETRES

CONSTANT LOAD                     =   16.44  N .
PROVING RING FACTOR               =  1.2365  N ./DIV
PISTON AREA                       =  5.0700 SQUARE CENTIMETRES

INITIAL DIAL READING              = 1588.00 DIVISIONS


SHEAR TEST RESULTS    START    131083     END    141083


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      PCSTRN   KPA       KPA       STRESS    KPA       STRESS    EFF SIFMA3
                                                                      KPA                 KPA

  1  1045    1588.0    237.5    199.9    0.0       89.9     48.2      20.8      41.7      62.1      1.864      0.0
  2  1100    1583.2    273.0    204.2    0.04      95.4     43.8      25.8      51.6      61.0      2.177      0.43
  3  1115    1575.5    300.2    207.3    0.11      99.7     40.6      29.6      59.1      60.3      2.456      0.42
  4  1130    1567.8    319.8    208.9    0.17     103.6     39.0      32.3      64.6      60.5      2.655      0.39
  5  1145    1557.8    338.0    210.2    0.26     107.3     37.7      34.8      69.6      60.9      2.846      0.37
  6  1200    1542.1    351.4    210.7    0.40     110.4     37.2      36.6      73.2      61.6      2.968      0.34
  7  1217    1532.5    361.5    210.8    0.48     113.0     37.0      38.0      76.0      62.3      3.053      0.32
  8  1231    1522.0    368.0    210.9    0.57     114.5     36.8      38.9      77.7      62.7      3.112      0.31
  9  1245    1510.8    372.2    210.5    0.67     116.1     37.3      39.4      78.8      63.6      3.113      0.29
 10  1310    1486.8    377.5    210.2    0.87     117.9     37.8      40.0      80.1      64.5      3.118      0.27
 11  1331    1469.2    380.0    209.9    1.03     118.7     38.1      40.3      80.6      65.0      3.117      0.26
 12  1345    1455.5    380.6    209.7    1.15     118.9     38.2      40.4      80.7      65.1      3.113      0.25
 13  1400    1441.8    382.5    209.6    1.26     119.5     38.3      40.6      81.2      65.4      3.119      0.25
 14  1415    1428.8    383.1    209.4    1.38     119.6     38.4      40.6      81.2      65.5      3.116      0.24
 15  1430    1414.5    383.5    209.3    1.50     119.7     38.4      40.6      81.3      65.5      3.116      0.24
 16  1445    1401.2    383.3    209.5    1.61     119.7     38.6      40.5      81.1      65.6      3.100      0.24
 17  1500    1387.7    384.0    209.5    1.73     119.7     38.5      40.6      81.2      85.6      3.108      0.24
 18  1520    1368.1    384.2    209.6    1.90     119.3     38.2      40.6      81.1      65.2      3.123      0.25
 19  1600    1331.0    384.2    209.9    2.22     118.7     37.8      40.4      80.9      64.8      3.139      0.26
 20  1637    1294.8    385.2    210.0    2.53     118.5     37.6      40.4      80.9      64.6      3.151      0.26
 21  1700    1273.9    385.5    210.6    2.71     118.2     37.4      40.4      80.8      64.3      3.160      0.27
 22  1730    1245.2    385.7    210.8    2.86     117.8     37.2      40.3      80.6      64.1      3.167      0.28
 23  1800    1217.1    385.4    211.0    3.21     117.2     36.9      40.2      80.3      63.7      3.177      0.29
 24  1830    1188.8    384.7    211.2    3.45     116.6     36.7      40.0      79.9      63.3      3.178      0.30
 25  1831    1188.0    382.5    RELAXATION TEST
 26  1832    1187.5    381.0    RELAXATION TEST
------------------------------------------------------------------------------------------------------------------------

 27  1834    1186.6    377.7    RELAXATION TEST
 28  1838    1185.3    373.0    RELAXATION TEST
 29  1845    1184.3    369.2    RELAXATION TEST
 30  1900    1182.8    363.2    RELAXATION TEST
 31  1930    1181.0    356.3    RELAXATION TEST
 32  2000    1180.0    352.3    RELAXATION TEST
 33  2030    1179.2    350.2    RELAXATION TEST
 34  2203    1177.8    343.8    RELAXATION TEST
 35   832    1175.0    332.5    RELAXATION TEST
 36   835    1175.0    333.5    210.4    3.57     103.8     37.8      33.0      66.0      59.8      2.747      0.43
 37   845    1172.2    357.0    212.4    3.59     108.1     35.8      36.2      72.3      59.9      3.021      0.41
 38   900    1164.3    379.0    213.5    3.66     112.7     34.5      39.1      78.2      60.6      3.268      0.37
 39   915    1152.0    388.8    213.3    3.77     115.5     34.7      40.4      80.8      61.6      3.328      0.34
 40   930    1138.5    390.6    212.8    3.89     116.3     35.1      40.6      81.2      62.2      3.313      0.33
 41   945    1123.8    389.8    212.3    4.01     116.4     35.5      40.4      80.9      62.5      3.278      0.32
 42  1000    1109.0    388.0    212.0    4.14     116.1     35.8      40.1      80.3      62.6      3.242      0.31
 43  1030    1081.1    385.5    211.8    4.38     115.4     36.0      39.7      79.4      62.5      3.206      0.32
 44  1130    1023.0    382.2    212.4    4.88     113.8     35.7      39.0      78.1      61.7      3.187      0.34
 45  1200     995.0    381.0    212.6    5.13     113.1     35.5      38.8      77.6      61.4      3.185      0.35
 46  1230     966.3    380.5    212.8    5.37     112.4     35.2      38.6      77.2      60.9      3.194      0.36
 47  1300     937.7    380.0    213.0    5.62     111.9     35.0      38.5      76.9      60.6      3.197      0.37
 48  1400     880.4    378.3    213.4    6.12     110.6     34.5      38.0      76.1      59.9      3.205      0.39
 49  1500     824.2    377.7    213.7    6.60     109.4     33.9      37.8      75.5      59.1      3.228      0.41
 50  1556     771.8    377.3    214.7    7.05     108.4     33.4      37.5      75.0      58.4      3.246      0.44
 51  1709     701.5    376.9    214.8    7.66     107.9     33.5      37.2      74.4      58.3      3.221      0.45
 52  1940     559.2    376.0    215.1    8.89     106.3     33.1      36.6      73.2      57.5      3.211      0.48
 53  2020     521.2    375.0    215.6    9.22     105.7     33.1      36.3      72.6      57.3      3.194      0.51
```

```
UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

SAMPLE NO. : T 704      (REMOULDED SAMPLE)

CONSOLIDATION AXIAL STRESS          :   48.00 KPA
PRECONSOLIDATION PRESSURE           :  160.04 KPA
NORMALIZING STRESS                  :  160.04 KPA

NORMALIZED SHEAR TEST RESULTS    START     131083      END     141083

 PT      PER        NRMLZD     EFFECT    NRMLZD     NRMLZD
         CENT       HALF       RATIO     OCT        CHANGE
         PCSTRN     DEV        SIGMA1    STRESS     IN PWP
                    STRESS     SIGMA3    KPA        KPA
                    KPA

  1      0.0        0.130      1.864     0.388      0.0
  2      0.04       0.161      2.177     0.381      0.027
  3      0.11       0.185      2.456     0.377      0.046
  4      0.17       0.202      2.655     0.378      0.056
  5      0.26       0.217      2.846     0.380      0.064
  6      0.40       0.229      2.968     0.385      0.067
  7      0.48       0.237      3.053     0.389      0.068
  8      0.57       0.243      3.112     0.392      0.069
  9      0.67       0.246      3.113     0.397      0.066
 10      0.87       0.250      3.118     0.403      0.064
 11      1.03       0.252      3.117     0.406      0.062
 12      1.15       0.252      3.113     0.407      0.061
 13      1.26       0.254      3.119     0.408      0.061
 14      1.38       0.254      3.116     0.409      0.059
 15      1.50       0.254      3.116     0.409      0.059
 16      1.61       0.253      3.100     0.410      0.060
 17      1.73       0.254      3.108     0.410      0.060
 18      1.90       0.253      3.123     0.408      0.061
 19      2.22       0.253      3.139     0.405      0.062
 20      2.53       0.253      3.151     0.403      0.063
 21      2.71       0.252      3.160     0.402      0.067
 22      2.96       0.252      3.167     0.400      0.068
 23      3.21       0.251      3.177     0.398      0.069
 24      3.45       0.250      3.178     0.396      0.071
 36      3.57       0.206      2.747     0.374      0.066
 37      3.59       0.226      3.021     0.374      0.078
 38      3.66       0.244      3.268     0.379      0.085
 39      3.77       0.252      3.328     0.385      0.084
 40      3.89       0.254      3.313     0.388      0.081
 41      4.01       0.253      3.278     0.390      0.077
 42      4.14       0.251      3.242     0.391      0.076
 43      4.38       0.248      3.206     0.390      0.074
 44      4.88       0.244      3.187     0.386      0.078
 45      5.13       0.242      3.185     0.383      0.079
 46      5.37       0.241      3.194     0.381      0.081
 47      5.62       0.240      3.197     0.379      0.082
--------------------------------------------------------------------------------------------------------------------

 48      6.12       0.238      3.205     0.374      0.084
 49      6.60       0.236      3.228     0.369      0.086
 50      7.05       0.234      3.246     0.365      0.092
 51      7.66       0.232      3.221     0.364      0.093
 52      8.89       0.229      3.211     0.359      0.095
 53      9.22       0.227      3.194     0.358      0.098
```

```
UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

SAMPLE NO. = T 706      (REMOULDED SAMPLE)
INITIAL MOISTURE CONTENT           =   47.3 PERCENT
SPECIFIC GRAVITY OF SOIL           =  2.73
INITIAL VOID RATIO                 =   1.292
INITIAL HEIGHT OF SAMPLE           =  12.60 CM
INITIAL VOLUME OF SAMPLE           =  571.52 CC
EFFECTIVE PRINCIPAL STRESS RATIO   =  1.00
FINAL MOISTURE CONTENT             =   40.0 PERCENT

TX.  CONSOLIDATION    START    211083     END      61183
TRIAXIAL CONSOLIDATION TEST
::::::::::::::::::::::::::



 PT  EFFECT    EFFECT   STRAIN1    VOLUME   STRAIN3    EFFECT        Q        VOID       V       SHEAR
     SIGMA1    SIGMA3              STRAIN                 P                  RATIO               STRAIN

  1   50.09     27.25    1.206      1.750    0.272     34.86     22.84     1.251     2.251     0.622
  2   57.55     31.30    1.451      2.222    0.386     40.05     26.25     1.241     2.241     0.710
  3   66.21     36.60    1.724      2.782    0.529     46.47     29.61     1.228     2.228     0.797
  4   76.13     42.20    2.794      3.867    0.536     53.51     33.93     1.203     2.203     1.505
  5   87.73     48.50    3.443      4.855    0.706     61.58     39.23     1.180     2.180     1.825
  6  101.04     55.80    4.235      5.897    0.831     70.88     45.24     1.156     2.156     2.270
  7  116.20     64.05    5.240      7.226    0.993     81.43     52.15     1.126     2.126     2.832
  8  133.73     73.60    6.405      8.469    1.032     93.64     60.13     1.097     2.097     3.582
  9  160.14     88.00    7.930     10.131    1.101    112.05     72.14     1.059     2.059     4.553
 10   79.79     44.00    7.173      8.766    0.796     55.93     35.79     1.091     2.091     4.251
 11   79.71     44.00    7.303      8.687    0.692     55.90     35.71     1.092     2.092     4.407
 12   75.30     45.30    7.303      8.687    0.692     55.30     30.00     1.092     2.092     4.407
 13   71.50     47.50    7.295      8.687    0.696     55.50     24.00     1.092     2.092     4.399
 14   68.10     50.10    7.272      8.687    0.708     56.10     18.00     1.092     2.092     4.377
 15   64.30     52.30    7.242      8.687    0.723     56.30     12.00     1.092     2.092     4.346
 16   60.10     54.10    7.195      8.687    0.746     56.10      6.00     1.092     2.092     4.300
 17   57.60     57.60    7.137      8.687    0.775     57.60      0.0      1.092     2.092     4.242
 18   56.90     56.90    7.112      8.687    0.788     56.90      0.0      1.092     2.092     4.216
 19   56.10     56.10    7.096      8.687    0.796     56.10      0.0      1.092     2.092     4.200
 20   55.60     55.60    7.082      8.687    0.803     55.60      0.0      1.092     2.092     4.186
 21   55.10     55.10    7.047      8.687    0.820     55.10      0.0      1.092     2.092     4.151
 22   54.80     54.80    7.015      8.687    0.836     54.80      0.0      1.092     2.092     4.119
 23   55.60     55.60    6.969      8.687    0.859     55.60      0.0      1.092     2.092     4.073
 24   53.70     53.70    6.915      8.687    0.886     53.70      0.0      1.092     2.092     4.019
 25   54.10     54.10    6.922      8.687    0.883     54.10      0.0      1.092     2.092     4.026
 26   54.90     54.90    6.914      8.687    0.886     54.90      0.0      1.092     2.092     4.019
 27   54.90     54.90    6.900      8.687    0.894     54.90      0.0      1.092     2.092     4.004
 28   55.10     55.10    6.878      8.687    0.905     55.10      0.0      1.092     2.092     3.982
 29   55.40     55.40    6.851      8.687    0.918     55.40      0.0      1.092     2.092     3.955

-----------------------------------------------------------------------------------------------------------

 30   55.50     55.50    6.838      8.687    0.925     55.50      0.0      1.092     2.092     3.942
 31   55.80     55.80    6.826      8.687    0.931     55.80      0.0      1.092     2.092     3.930
 32   55.10     55.10    6.818      8.687    0.935     55.10      0.0      1.092     2.092     3.922
 33   54.50     54.50    6.791      8.687    0.948     54.50      0.0      1.092     2.092     3.895
 34   53.60     53.60    6.780      8.687    0.954     53.60      0.0      1.092     2.092     3.884
 35   52.50     52.50    6.748      8.687    0.970     52.50      0.0      1.092     2.092     3.852
```

```
SUMMARY OF ESSENTIAL RESULTS STORED IN FILE


 PT  SIGMA1    SIGMA3    STRAIN1    STRAIN3      V

  1   50.09     27.26     1.206      0.272     2.251
  2   57.55     31.30     1.451      0.386     2.241
  3   66.21     36.60     1.724      0.529     2.228
  4   76.13     42.20     2.794      0.536     2.203
  5   87.73     48.50     3.443      0.706     2.180
  6  101.04     55.80     4.235      0.831     2.156
  7  116.20     64.05     5.240      0.993     2.126
  8  133.73     73.60     6.405      1.032     2.087
  9  160.14     88.00     7.930      1.101     2.059
 10   79.79     44.00     7.173      0.796     2.091
 11   79.71     44.00     7.303      0.692     2.092
 12   75.30     45.30     7.303      0.692     2.092
 13   71.50     47.50     7.295      0.696     2.092
 14   68.10     50.10     7.272      0.708     2.092
 15   64.30     52.30     7.242      0.723     2.092
 16   60.10     54.10     7.195      0.746     2.092
 17   57.60     57.60     7.137      0.775     2.092
 18   56.90     56.90     7.112      0.788     2.092
 19   56.10     56.10     7.095      0.796     2.092
 20   55.60     55.60     7.082      0.803     2.092
 21   55.10     55.10     7.047      0.820     2.092
 22   54.80     54.80     7.015      0.836     2.092
 23   55.60     55.60     6.969      0.859     2.092
 24   53.70     53.70     6.915      0.886     2.092
 25   54.10     54.10     6.922      0.883     2.092
 26   54.90     54.90     6.914      0.886     2.092
 27   54.90     54.90     6.900      0.894     2.092
 28   55.10     55.10     6.878      0.905     2.092
 29   55.40     55.40     6.851      0.918     2.092
 30   55.50     55.50     6.838      0.925     2.092
 31   55.80     55.80     6.826      0.931     2.092
 32   55.10     55.10     6.818      0.935     2.092
 33   54.50     54.50     6.791      0.948     2.092
 34   53.80     53.80     6.780      0.954     2.092
 35   52.50     52.50     6.748      0.970     2.092
```

```
UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

ENERGY CALCULATIONS

****  ENGINEERING STRAIN  ****

SAMPLE NO. : T 706     (REMOULDED SAMPLE)
TEST RESULTS     START    211083      END      61183


 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     50.1      27.3      22.8      34.9     1.206    0.272     1.750      0.0     0.0                0.0
                                                                                               0.199
  2     57.6      31.3      26.3      40.1     1.451    0.386     2.222      9.4     0.3                0.199
                                                                                               0.266
  3     66.2      36.6      29.6      46.5     1.724    0.529     2.782     20.8     0.6                0.465
                                                                                               0.767
  4     76.1      42.2      33.9      53.5     2.794    0.536     3.867     33.5     1.6                1.232
                                                                                               0.686
  5     87.7      48.5      39.2      61.6     3.443    0.706     4.855     48.2     2.3                1.918
                                                                                               0.877
  6    101.0      55.8      45.2      70.9     4.235    0.831     5.897     65.0     3.1                2.796
                                                                                               1.286
  7    116.2      64.1      52.1      81.4     5.240    0.993     7.226     84.1     4.2                4.082
                                                                                               1.509
  8    133.7      73.6      60.1      93.6     6.405    1.032     8.469    106.3     5.3                5.590
                                                                                               2.352
  9    160.1      88.0      72.1     112.0     7.930    1.101    10.131    139.5     6.8                7.942
                                                                                              -1.309
 10     79.8      44.0      35.8      55.9     7.173    0.796     8.766     38.0     6.0                6.633
                                                                                               0.012
 11     79.7      44.0      35.7      55.9     7.303    0.692     8.687     37.9     6.1                6.645
                                                                                               0.0
 12     75.3      45.3      30.0      55.3     7.303    0.692     8.687     35.9     6.1                6.645
                                                                                              -0.002
 13     71.5      47.5      24.0      55.5     7.295    0.696     8.687     35.6     6.1                6.642
                                                                                              -0.005
 14     68.1      50.1      18.0      56.1     7.272    0.708     8.687     37.0     6.1                6.638
                                                                                              -0.005
 15     64.3      52.3      12.0      56.3     7.242    0.723     8.687     38.2     6.1                6.633
                                                                                              -0.004
 16     60.1      54.1       6.0      56.1     7.195    0.746     8.687     39.3     6.0                6.629
                                                                                              -0.002
 17     57.6      57.6       0.0      57.6     7.137    0.775     8.687     43.6     6.0                6.627
                                                                                               0.0
 18     56.9      56.9       0.0      56.9     7.112    0.788     8.687     42.5     6.0                6.627
                                                                                               0.0
 19     56.1      56.1       0.0      56.1     7.095    0.796     8.687     41.2     5.9                6.627
```

```
                                                                                   0.0
 20    55.6     55.6     0.0     55.6     7.082   0.803    8.687    40.5   5.9              6.827
                                                                                   0.0
 21    55.1     55.1     0.0     55.1     7.047   0.820    8.687    39.7   5.9              6.827
                                                                                   0.0
 22    54.8     54.8     0.0     54.8     7.015   0.836    8.687    39.2   5.9              6.827
                                                                                   0.0
 23    55.6     55.6     0.0     55.6     6.969   0.859    8.687    40.5   5.8              6.827
                                                                                   0.0
 24    53.7     53.7     0.0     53.7     6.915   0.886    8.687    37.6   5.8              6.827
                                                                                   0.0
 25    54.1     54.1     0.0     54.1     6.922   0.883    8.687    38.2   5.8              6.827
                                                                                   0.0
 26    54.9     54.9     0.0     54.9     6.914   0.886    8.687    39.4   5.8              6.827
                                                                                   0.0
 27    54.9     54.9     0.0     54.9     6.900   0.894    8.687    39.4   5.8              6.827
                                                                                   0.0
 28    55.1     55.1     0.0     55.1     6.878   0.905    8.687    39.7   5.7              6.827
                                                                                   0.0
 29    55.4     55.4     0.0     55.4     6.851   0.918    8.687    40.2   5.7              6.827
                                                                                   0.0
 30    55.5     55.5     0.0     55.5     6.836   0.925    8.687    40.3   5.7              6.827
                                                                                   0.0
 31    55.8     55.8     0.0     55.8     6.826   0.931    8.687    40.8   5.7              6.827
                                                                                   0.0
 32    55.1     55.1     0.0     55.1     6.818   0.935    8.687    39.7   5.7              6.827
                                                                                   0.0
 33    54.5     54.5     0.0     54.5     6.791   0.948    8.687    38.8   5.7              6.827
                                                                                   0.0
 34    53.6     53.6     0.0     53.6     6.780   0.954    8.687    37.4   5.7              6.827
                                                                                   0.0
 35    52.5     52.5     0.0     52.5     6.746   0.970    8.687    35.8   5.6              6.827
```

```
UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

ENERGY CALCULATIONS

****     NATURAL STRAIN     ****

SAMPLE NO. : T 706       (REMOULDED SAMPLE)
TEST RESULTS     START     211083      END      61183

 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    50.1     27.3     22.8     34.9    1.213   0.276    1.765     0.0   0.0              0.0
                                                                                   0.202
  2    57.6     31.3     26.3     40.1    1.462   0.393    2.247     9.4   0.3              0.202
                                                                                   0.272
  3    66.2     36.6     29.6     46.5    1.739   0.541    2.821    20.8   0.6              0.476
                                                                                   0.780
  4    76.1     42.2     33.9     53.5    2.834   0.555    3.944    33.6   1.7              1.264
                                                                                   0.714
  5    87.7     48.5     39.2     61.6    3.504   0.737    4.977    48.2   2.4              1.978
                                                                                   0.922
  6   101.0     55.8     45.2     70.9    4.326   0.875    6.077    65.0   3.2              2.900
                                                                                   1.368
  7   116.2     64.1     52.1     81.4    5.383   1.059    7.501    84.1   4.3              4.267
                                                                                   1.622
  8   133.7     73.6     60.1     93.6    6.619   1.115    8.849   106.3   5.5              5.889
                                                                                   2.567
  9   160.1     88.0     72.1    112.0    8.262   1.210   10.681   139.6   7.2              8.456
                                                                                  -1.436
 10    79.8     44.0     35.8     55.9    7.443   0.865    9.174    38.0   6.3              7.019
                                                                                   0.012
 11    79.7     44.0     35.7     55.9    7.583   0.753    9.088    37.9   6.4              7.031
                                                                                   0.0
 12    75.3     45.3     30.0     55.3    7.583   0.753    9.088    35.9   6.4              7.031
                                                                                  -0.002
 13    71.5     47.5     24.0     55.5    7.574   0.757    9.088    35.8   6.4              7.029
                                                                                  -0.005
 14    68.1     50.1     18.0     56.1    7.550   0.769    9.088    37.0   6.4              7.024
                                                                                  -0.005
 15    64.3     52.3     12.0     56.3    7.518   0.785    9.088    38.2   6.3              7.019
                                                                                  -0.005
 16    60.1     54.1      6.0     56.1    7.467   0.810    9.088    38.3   6.3              7.014
                                                                                  -0.002
 17    57.6     57.6      0.0     57.6    7.405   0.842    9.088    43.6   6.2              7.013
                                                                                  -0.000
 18    56.9     56.9      0.0     56.9    7.377   0.855    9.088    42.5   6.2              7.013
                                                                                  -0.000
 19    56.1     56.1      0.0     56.1    7.380   0.854    9.088    41.2   6.2              7.013
```

20	55.6	55.6	0.0	55.6	7.345	0.871	9.088	40.5	6.2	0.0	7.013
21	55.1	55.1	0.0	55.1	7.307	0.890	9.088	39.7	6.2	-0.000	7.013
22	54.8	54.8	0.0	54.8	7.273	0.907	9.088	39.2	6.1	-0.000	7.013
23	55.6	55.6	0.0	55.6	7.224	0.932	9.088	40.5	6.1	-0.000	7.013
24	53.7	53.7	0.0	53.7	7.166	0.951	9.088	37.6	6.0	-0.000	7.013
25	54.1	54.1	0.0	54.1	7.173	0.958	9.088	38.2	6.0	-0.000	7.013
26	54.9	54.9	0.0	54.9	7.155	0.961	9.088	39.4	6.0	-0.000	7.013
27	54.9	54.9	0.0	54.9	7.150	0.969	9.088	39.4	6.0	-0.000	7.013
28	55.1	55.1	0.0	55.1	7.126	0.981	9.088	39.7	6.0	-0.000	7.013
29	55.4	55.4	0.0	55.4	7.097	0.996	9.088	40.2	6.0	-0.000	7.013
30	55.5	55.5	0.0	55.5	7.083	1.002	9.088	40.3	6.0	-0.000	7.013
31	55.8	55.8	0.0	55.8	7.070	1.009	9.088	40.8	5.9	-0.000	7.013
32	55.1	55.1	0.0	55.1	7.061	1.013	9.088	39.7	5.9	-0.000	7.013
33	54.5	54.5	0.0	54.5	7.032	1.028	9.088	38.8	5.9	-0.000	7.013
34	53.6	53.6	0.0	53.6	7.021	1.033	9.088	37.4	5.9	-0.000	7.013
35	52.5	52.5	0.0	52.5	6.986	1.051	9.088	35.8	5.9	-0.000	7.013

```
UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

SAMPLE NO. : T 706      (REMOULDED SAMPLE)

SAMPLE HEIGHT AFTER CONSOLIDATION :  11.761 CENTIMETRES
SAMPLE VOLUME AFTER CONSOLIDATION : 523.070 CUBIC CENTIMETRES
SAMPLE AREA AFTER CONSOLIDATION   :  44.475 SQUARE CENTIMETRES

CONSTANT LOAD                     :   16.52  N .
PROVING RING FACTOR               :  1.0225  N ./DIV
PISTON AREA                       :  5.0700 SQUARE CENTIMETRES

INITIAL DIAL READING              : 1162.50 DIVISIONS


SHEAR TEST RESULTS     START      71183      END      91183


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      PCSTRN   KPA       KPA       STRESS    KPA       STRESS    EFF SIFMA3
                                                                       KPA                 KPA

  1   852     1162.5    120.0    200.2    0.0        51.1      48.1       1.5       3.0      49.1       1.062      0.0
  2   902     1161.5    148.2    202.4    0.01       55.4      45.9       4.7       9.5      49.1       1.207      0.34
  3   923     1155.0    197.5    206.8    0.06       62.5      41.7      10.4      20.8      48.6       1.498      0.37
  4   932     1150.8    217.0    208.7    0.10       65.0      39.7      12.6      25.3      48.1       1.636      0.38
  5   945     1145.0    241.5    210.5    0.15       68.8      37.9      15.4      30.9      48.2       1.815      0.37
  6  1000     1136.9    267.5    212.6    0.22       72.7      35.9      18.4      36.8      48.2       2.025      0.37
  7  1015     1128.8    288.9    213.9    0.29       76.2      34.5      20.8      41.7      48.4       2.209      0.35
  8  1030     1120.6    309.2    215.2    0.36       79.7      33.4      23.1      46.3      48.8       2.386      0.35
  9  1045     1111.6    327.4    216.2    0.43       82.8      32.4      25.2      50.4      49.2       2.556      0.34
 10  1100     1101.2    345.2    217.2    0.52       85.9      31.4      27.2      54.5      49.6       2.734      0.33
 11  1115     1092.0    360.8    217.6    0.60       89.0      31.0      29.0      58.0      50.3       2.870      0.32
 12  1132     1080.0    376.4    218.0    0.70       92.0      30.5      30.7      61.5      51.0       3.016      0.30
 13  1145     1069.3    388.0    218.2    0.79       94.5      30.4      32.0      64.1      51.8       3.108      0.29
 14  1200     1058.8    399.0    218.2    0.88       96.9      30.4      33.3      66.5      52.6       3.188      0.28
 15  1215     1048.0    408.3    217.9    0.97       99.3      30.7      34.3      68.6      53.6       3.234      0.27
 16  1230     1036.0    415.5    217.9    1.08      100.8      30.6      35.1      70.2      54.0       3.293      0.26
 17  1245     1023.7    422.8    217.3    1.18      102.8      31.1      35.9      71.7      55.0       3.307      0.25
 18  1300     1011.4    428.5    217.2    1.28      104.3      31.4      36.5      72.9      55.7       3.323      0.24
 19  1315      999.4    433.2    217.0    1.39      105.5      31.6      37.0      73.9      56.2       3.340      0.24
 20  1330      985.9    437.0    216.6    1.50      106.5      31.8      37.4      74.7      56.7       3.350      0.23
 21  1345      971.7    439.9    216.3    1.62      107.5      32.2      37.6      75.3      57.3       3.338      0.22
 22  1402      957.3    442.9    216.2    1.74      108.1      32.2      37.9      75.9      57.5       3.356      0.22
 23  1415      944.3    445.6    216.0    1.86      108.8      32.4      38.2      76.4      57.9       3.358      0.22
 24  1430      931.1    447.6    215.7    1.97      109.6      32.8      38.4      76.8      58.4       3.340      0.21
 25  1447      915.2    449.5    215.5    2.10      110.0      32.9      38.5      77.1      58.6       3.343      0.21
 26  1503      901.0    451.1    215.5    2.22      110.4      33.1      38.7      77.3      58.9       3.336      0.21
--------------------------------------------------------------------------------------------------------------------------

 27  1515      889.8    452.2    215.2    2.32      110.9      33.4      38.8      77.5      59.2       3.320      0.20
 28  1530      875.2    453.2    215.2    2.44      110.9      33.3      38.8      77.6      59.2       3.332      0.20
 29  1545      863.0    453.9    215.2    2.55      111.0      33.3      38.9      77.7      59.2       3.334      0.20
 30  1600      848.8    455.1    215.0    2.67      111.4      33.5      38.9      77.9      59.5       3.325      0.20
 31  1615      835.0    455.7    214.8    2.78      111.7      33.8      39.0      77.9      59.8       3.305      0.19
 32  1630      821.0    456.0    215.2    2.90      111.4      33.5      38.9      77.9      59.5       3.325      0.20
 33  1649      802.9    456.7    215.0    3.06      111.5      33.6      39.0      77.9      59.6       3.319      0.20
 34  1702      790.9    457.2    215.1    3.16      111.4      33.5      39.0      77.9      59.5       3.327      0.20
 35  1729      765.2    458.8    215.2    3.38      111.6      33.5      39.1      78.1      59.5       3.332      0.20
 36  1731      764.0    455.8    RELAXATION TEST
 37  1733      763.2    453.2    RELAXATION TEST
 38  1735      762.6    451.0    RELAXATION TEST
 39  1740      761.3    446.2    RELAXATION TEST
 40  1750      759.7    440.8    RELAXATION TEST
 41  1800      758.7    436.8    RELAXATION TEST
 42  1816      757.9    432.8    RELAXATION TEST
 43  1837      756.8    429.0    RELAXATION TEST
 44  1915      756.2    424.4    RELAXATION TEST
 45  2113      753.5    417.2    RELAXATION TEST
 46  2227      752.7    414.6    RELAXATION TEST
 47   815      750.2    405.1    RELAXATION TEST
 48   952      750.0    404.2    RELAXATION TEST
 49  1004      749.4    404.0    213.8    3.51      100.3      34.4      33.0      65.9      56.4       2.916      0.22
 50  1015      747.0    430.2    215.6    3.53      104.3      32.6      35.9      71.7      56.5       3.199      0.22
 51  1031      737.3    454.2    216.5    3.62      108.7      31.7      38.5      77.0      57.4       3.428      0.22
 52  1045      726.2    461.5    216.4    3.71      110.3      31.8      39.3      78.5      58.0       3.469      0.21
 53  1107      706.2    464.8    215.7    3.88      111.6      32.5      39.5      79.1      58.9       3.434      0.20
 54  1117      697.2    465.1    215.3    3.96      111.9      32.8      39.6      79.1      59.2       3.412      0.20
 55  1130      685.2    464.4    215.0    4.06      112.0      33.1      39.4      78.9      59.4       3.383      0.20
 56  1145      671.8    464.2    215.0    4.17      112.0      33.3      39.4      78.7      59.5       3.364      0.20
 57  1200      656.2    463.8    214.7    4.30      112.0      33.5      39.3      78.5      59.7       3.344      0.19
 58  1232      625.9    462.8    214.8    4.56      111.4      33.3      39.1      78.1      59.3       3.345      0.19
 59  1300      600.0    463.1    214.9    4.78      111.4      33.4      39.0      78.0      59.4       3.334      0.20
 60  1330      571.0    463.2    214.8    5.03      111.1      33.3      38.9      77.8      59.2       3.337      0.20
 61  1400      543.1    463.3    215.0    5.27      110.7      33.1      38.8      77.6      59.0       3.345      0.20
 62  1512      474.8    463.2    215.1    5.85      110.4      33.3      38.6      77.1      59.0       3.315      0.20
 63  1600      428.0    463.3    215.5    6.25      109.7      32.9      38.4      76.8      58.5       3.334      0.21
 64  1920      239.2    463.0    216.0    7.85      107.7      32.3      37.7      75.4      57.4       3.335      0.22
 65  2045      159.0    463.1    216.3    8.53      107.0      32.1      37.4      74.9      57.1       3.333      0.22
 66   823     -490.5    472.2    217.4   14.06      102.8      30.6      36.1      72.2      54.7       3.360      0.25
 67   907     -532.2    473.5    217.4   14.41      102.8      30.6      36.1      72.2      54.7       3.358      0.25
 68   945     -566.8    474.8    217.5   14.70      102.7      30.5      36.1      72.2      54.6       3.366      0.25
 69  1031     -610.2    474.6    217.6   15.07      102.2      30.4      35.9      71.8      54.3       3.362      0.25
```

```
UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

SAMPLE NO. = T 706      (REMOULDED SAMPLE)

CONSOLIDATION AXIAL STRESS         =    48.00 KPA
PRECONSOLIDATION PRESSURE          =   160.14 KPA
NORMALIZING STRESS                 =   160.14 KPA

NORMALIZED SHEAR TEST RESULTS     START      71183      END      91183

 PT     PER         NRMLZD      EFFECT     NRMLZD      NRMLZD
        CENT        HALF        RATIO      OCT         CHANGE
        PCSTRN      DEV         SIGMA1     STRESS      IN PWP
                    STRESS      SIGMA3     KPA         KPA
                    KPA

  1     0.0         0.009       1.062      0.307       0.0
  2     0.01        0.030       1.207      0.306       0.014
  3     0.06        0.065       1.498      0.304       0.041
  4     0.10        0.079       1.636      0.300       0.053
  5     0.15        0.096       1.815      0.301       0.064
  6     0.22        0.115       2.025      0.301       0.077
  7     0.29        0.130       2.209      0.302       0.086
  8     0.36        0.145       2.386      0.305       0.094
  9     0.43        0.157       2.556      0.307       0.100
 10     0.52        0.170       2.734      0.309       0.106
 11     0.60        0.181       2.870      0.314       0.109
 12     0.70        0.192       3.016      0.318       0.111
 13     0.79        0.200       3.108      0.323       0.112
 14     0.88        0.208       3.188      0.328       0.112
 15     0.97        0.214       3.234      0.334       0.111
 16     1.08        0.219       3.293      0.337       0.111
 17     1.18        0.224       3.307      0.344       0.107
 18     1.28        0.228       3.323      0.348       0.106
 19     1.39        0.231       3.340      0.351       0.105
 20     1.50        0.233       3.350      0.354       0.102
 21     1.62        0.235       3.338      0.358       0.101
 22     1.74        0.237       3.356      0.359       0.100
 23     1.86        0.239       3.358      0.361       0.099
 24     1.97        0.240       3.340      0.365       0.097
 25     2.10        0.241       3.343      0.366       0.096
 26     2.22        0.241       3.336      0.368       0.096
 27     2.32        0.242       3.320      0.370       0.094
 28     2.44        0.242       3.332      0.370       0.094
 29     2.55        0.243       3.334      0.370       0.094
 30     2.67        0.243       3.325      0.371       0.092
 31     2.78        0.243       3.305      0.373       0.091
 32     2.90        0.243       3.325      0.371       0.094
 33     3.06        0.243       3.319      0.372       0.092
 34     3.16        0.243       3.327      0.371       0.093
 35     3.38        0.244       3.332      0.372       0.094
 49     3.51        0.206       2.916      0.352       0.085
-----------------------------------------------------------------------------------------------------------------

 50     3.53        0.224       3.199      0.353       0.096
 51     3.62        0.240       3.428      0.358       0.102
 52     3.71        0.245       3.469      0.362       0.101
 53     3.88        0.247       3.434      0.368       0.097
 54     3.96        0.247       3.412      0.369       0.094
 55     4.06        0.246       3.383      0.371       0.092
 56     4.17        0.246       3.364      0.372       0.092
 57     4.30        0.245       3.344      0.373       0.091
 58     4.56        0.244       3.345      0.371       0.091
 59     4.78        0.243       3.334      0.371       0.092
 60     5.03        0.243       3.337      0.370       0.091
 61     5.27        0.242       3.345      0.368       0.092
 62     5.85        0.241       3.315      0.368       0.093
 63     6.25        0.240       3.334      0.365       0.096
 64     7.85        0.236       3.335      0.359       0.099
 65     8.53        0.234       3.333      0.356       0.101
 66    14.06        0.225       3.360      0.341       0.107
 67    14.41        0.225       3.358      0.341       0.107
 68    14.70        0.225       3.366      0.341       0.108
 69    15.07        0.224       3.362      0.339       0.109
```

```
UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

SAMPLE NO. : T 708      (REMOULDED SAMPLE)
INITIAL MOISTURE CONTENT           :   45.8 PERCENT
SPECIFIC GRAVITY OF SOIL           :  2.73
INITIAL VOID RATIO                 :   1.250
INITIAL HEIGHT OF SAMPLE           :  12.65 CM
INITIAL VOLUME OF SAMPLE           :  573.94 CC
EFFECTIVE PRINCIPAL STRESS RATIO   :  1.00
FINAL MOISTURE CONTENT             :   38.8 PERCENT

TX. CONSOLIDATION     START      11183     END     151183
TRIAXIAL CONSOLIDATION TEST
::::::::::::::::::::::::::



 PT  EFFECT     EFFECT   STRAIN1    VOLUME   STRAIN3    EFFECT       Q         VOID        V       SHEAR
     SIGMA1     SIGMA3              STRAIN                P                    RATIO               STRAIN

  1    50.21     27.50    0.779     1.620     0.421     35.07     22.71      1.213     2.213     0.238
  2    57.55     31.50    1.018     2.091     0.536     40.18     26.05      1.203     2.203     0.321
  3    66.26     36.20    1.325     2.666     0.671     46.22     30.06      1.190     2.190     0.436
  4    76.37     41.60    1.843     3.537     0.847     53.19     34.77      1.170     2.170     0.664
  5    87.77     47.80    2.528     4.530     1.001     61.12     39.97      1.148     2.148     1.018
  6   100.93     54.80    3.376     5.680     1.152     70.18     46.13      1.122     2.122     1.482
  7   116.10     62.90    4.365     6.995     1.315     80.63     53.20      1.092     2.092     2.033
  8   133.49     72.20    5.422     8.276     1.427     92.63     61.29      1.064     2.064     2.663
  9   160.20     86.60    6.975     9.987     1.506    111.13     73.60      1.025     2.025     3.646
 10    79.69     43.30    6.258     8.616     1.179     55.43     36.39      1.056     2.056     3.386
 11    79.64     43.30    6.435     8.485     1.025     55.41     36.34      1.059     2.059     3.607
 12    74.70     44.00    6.438     8.485     1.024     54.23     30.70      1.059     2.059     3.609
 13    69.00     44.30    6.438     8.485     1.024     52.53     24.70      1.059     2.059     3.609
 14    64.70     46.00    6.429     8.485     1.028     52.23     18.70      1.059     2.059     3.601
 15    60.30     47.60    6.408     8.485     1.039     51.83     12.70      1.059     2.059     3.579
 16    56.10     49.40    6.374     8.485     1.055     51.63      6.70      1.059     2.059     3.546
 17    51.50     51.50    6.333     8.485     1.076     51.50      0.0       1.059     2.059     3.505
 18    51.10     51.10    6.316     8.485     1.085     51.10      0.0       1.059     2.059     3.488
 19    51.00     51.00    6.250     8.485     1.118     51.00      0.0       1.059     2.059     3.421
 20    51.00     51.00    6.201     8.485     1.142     51.00      0.0       1.059     2.059     3.373
 21    50.90     50.90    6.137     8.485     1.174     50.90      0.0       1.059     2.059     3.309
 22    50.90     50.90    6.005     8.485     1.240     50.90      0.0       1.059     2.059     3.178
 23    50.80     50.80    5.973     8.485     1.256     50.80      0.0       1.059     2.059     3.145
 24    50.40     50.40    5.975     8.485     1.255     50.40      0.0       1.059     2.059     3.146
 25    51.20     51.20    5.929     8.485     1.278     51.20      0.0       1.059     2.059     3.101
 26    51.50     51.50    5.873     8.485     1.306     51.50      0.0       1.059     2.059     3.044
 27    42.40     42.40    5.812     8.485     1.337     42.40      0.0       1.059     2.059     2.983
 28    40.70     40.70    5.733     8.485     1.376     40.70      0.0       1.059     2.059     2.905
 29    36.00     36.00    5.592     8.485     1.447     36.00      0.0       1.059     2.059     2.764
----------------------------------------------------------------------------------------------------------------

 30    33.60     33.60    5.549     8.485     1.468     33.60      0.0       1.059     2.059     2.721
 31    31.70     31.70    5.497     8.485     1.494     31.70      0.0       1.059     2.059     2.669
 32    29.70     29.70    5.439     8.485     1.523     29.70      0.0       1.059     2.059     2.611
 33    30.00     30.00    5.399     8.485     1.543     30.00      0.0       1.059     2.059     2.571
 34    29.20     29.20    5.353     8.485     1.566     29.20      0.0       1.059     2.059     2.525
```

```
SUMMARY OF ESSENTIAL RESULTS STORED IN FILE


 PT   SIGMA1     SIGMA3     STRAIN1     STRAIN3       V

  1    50.21      27.50      0.779       0.421      2.213
  2    57.55      31.50      1.018       0.535      2.203
  3    66.28      36.20      1.325       0.671      2.190
  4    76.37      41.60      1.843       0.847      2.170
  5    87.77      47.80      2.526       1.001      2.148
  6   100.93      54.80      3.376       1.152      2.122
  7   116.10      62.90      4.365       1.315      2.092
  8   133.49      72.20      5.422       1.427      2.064
  9   160.20      86.60      6.875       1.506      2.025
 10    79.69      43.30      6.258       1.179      2.058
 11    79.64      43.30      6.435       1.025      2.059
 12    74.70      44.00      6.438       1.024      2.059
 13    69.00      44.30      6.438       1.024      2.059
 14    64.70      46.00      6.429       1.028      2.059
 15    60.30      47.60      6.408       1.038      2.059
 16    56.10      49.40      6.374       1.055      2.059
 17    51.50      51.50      6.333       1.076      2.059
 18    51.10      51.10      6.316       1.085      2.059
 19    51.00      51.00      6.250       1.118      2.059
 20    51.00      51.00      6.201       1.142      2.059
 21    50.90      50.90      6.137       1.174      2.059
 22    50.90      50.90      6.006       1.240      2.059
 23    50.80      50.80      5.973       1.256      2.059
 24    50.40      50.40      5.975       1.255      2.059
 25    51.20      51.20      5.929       1.278      2.059
 26    51.50      51.50      5.873       1.306      2.059
 27    42.40      42.40      5.812       1.337      2.059
 28    40.70      40.70      5.733       1.376      2.059
 29    36.00      36.00      5.592       1.447      2.059
 30    33.60      33.60      5.549       1.468      2.059
 31    31.70      31.70      5.497       1.494      2.059
 32    29.70      29.70      5.439       1.523      2.059
 33    30.00      30.00      5.399       1.543      2.059
 34    29.20      29.20      5.353       1.566      2.059
```

```
UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

ENERGY CALCULATIONS

****  ENGINEERING STRAIN  ****

SAMPLE NO. : T 708      (REMOULDED SAMPLE)
TEST RESULTS      START      11183      END     151183


 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    50.2      27.5     22.7      35.1     0.779    0.421    1.620      0.0    0.0                0.0
                                                                                         0.197
  2    57.6      31.5     26.1      40.2     1.018    0.535    2.091      8.3    0.3                0.197
                                                                                         0.281
  3    66.3      36.2     30.1      46.2     1.325    0.671    2.666     20.2    0.7                0.478
                                                                                         0.507
  4    76.4      41.6     34.8      53.2     1.843    0.847    3.537     32.9    1.2                0.985
                                                                                         0.700
  5    87.8      47.8     40.0      61.1     2.526    1.001    4.530     47.3    1.9                1.685
                                                                                         0.955
  6   100.9      54.8     46.1      70.2     3.376 .  1.152    5.680     63.7    2.6                2.639
                                                                                         1.265
  7   116.1      62.9     53.2      80.6     4.365    1.315    6.995     82.6    3.6                3.905
                                                                                         1.470
  8   133.5      72.2     61.3      92.6     5.422    1.427    8.276    104.6    4.9                5.375
                                                                                         2.406
  9   160.2      86.6     73.6     111.1     6.875    1.506    9.887    136.1    6.4                7.781
                                                                                        -1.285
 10    79.7      43.3     36.4      55.4     6.258    1.179    8.616     37.0    5.6                6.496
                                                                                         0.008
 11    79.6      43.3     36.3      55.4     6.435    1.025    8.485     37.0    5.7                6.504
                                                                                         0.001
 12    74.7      44.0     30.7      54.2     6.438    1.024    8.485     33.6    5.7                6.505
                                                                                         0.0
 13    69.0      44.3     24.7      52.5     6.438    1.024    8.486     30.3    5.7                6.505
                                                                                        -0.002
 14    64.7      46.0     18.7      52.2     6.429    1.028    8.485     29.9    5.7                6.503
                                                                                        -0.003
 15    60.3      47.6     12.7      51.8     6.408    1.039    8.485     30.2    5.7                6.500
                                                                                        -0.003
 16    56.1      49.4      6.7      51.6     6.374    1.055    8.485     31.5    5.7                6.496
                                                                                        -0.001
 17    51.5      51.5      0.0      51.5     6.333    1.076    8.485     34.0    5.6                6.495
                                                                                        -0.000
 18    51.1      51.1      0.0      51.1     6.316    1.085    8.485     33.4    5.6                6.495
                                                                                         0.000
 19    51.0      51.0      0.0      51.0     6.250    1.118    8.485     33.2    5.6                6.495
```

```
                                                                                       0.0
 20    51.0     51.0     0.0     51.0     6.201   1.142    8.485     33.2   5.5                 6.495
                                                                                     -0.000
 21    50.9     50.9     0.0     50.9     6.137   1.174    8.485     33.1   5.5                 6.495
                                                                                       0.000
 22    50.9     50.9     0.0     50.9     6.005   1.240    8.485     33.1   5.4                 6.495
                                                                                       0.0
 23    50.6     50.6     0.0     50.6     5.973   1.256    8.485     33.0   5.3                 6.495
                                                                                       0.0
 24    50.4     50.4     0.0     50.4     5.975   1.255    8.485     32.4   5.3                 6.495
                                                                                     -0.000
 25    51.2     51.2     0.0     51.2     5.929   1.278    8.485     33.5   5.3                 6.495
                                                                                       0.000
 26    51.5     51.5     0.0     51.5     5.873   1.306    8.485     34.0   5.2                 6.495
                                                                                       0.0
 27    42.4     42.4     0.0     42.4     5.812   1.337    8.485     22.5   5.2                 6.495
                                                                                       0.0
 28    40.7     40.7     0.0     40.7     5.733   1.376    8.485     21.0   5.1                 6.495
                                                                                       0.0
 29    36.0     36.0     0.0     36.0     5.592   1.447    8.485     18.6   5.0                 6.495
                                                                                       0.0
 30    33.6     33.6     0.0     33.6     5.549   1.468    8.485     18.7   5.0                 6.495
                                                                                       0.0
 31    31.7     31.7     0.0     31.7     5.497   1.494    8.485     19.4   5.0                 6.495
                                                                                     -0.000
 32    29.7     29.7     0.0     29.7     5.439   1.523    8.485     20.7   4.9                 6.495
                                                                                       0.0
 33    30.0     30.0     0.0     30.0     5.399   1.543    8.485     20.5   4.9                 6.495
                                                                                       0.000
 34    29.2     29.2     0.0     29.2     5.353   1.566    8.485     21.1   4.9                 6.495
```

```
UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

ENERGY CALCULATIONS

****     NATURAL STRAIN     ****

SAMPLE NO. : T 706      (REMOULDED SAMPLE)
TEST RESULTS     START      11183      END     161183

 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    50.2     27.5    22.7     35.1     0.782   0.428    1.634      0.0   0.0              0.0
                                                                                    0.200
  2    57.6     31.5    26.1     40.2     1.023   0.545    2.113      9.3   0.3              0.200
                                                                                    0.288
  3    66.3     36.2    30.1     46.2     1.334   0.684    2.702     20.2   0.7              0.487
                                                                                    0.521
  4    76.4     41.6    34.8     53.2     1.860   0.870    3.601     32.9   1.2              1.007
                                                                                    0.724
  5    87.8     47.8    40.0     61.1     2.561   1.037    4.636     47.3   2.0              1.732
                                                                                    0.996
  6   100.9     54.8    46.1     70.2     3.434   1.207    5.848     63.7   2.8              2.729
                                                                                    1.337
  7   116.1     62.9    53.2     80.6     4.483   1.385    7.252     82.8   3.9              4.067
                                                                                    1.573
  8   133.5     72.2    61.3     92.6     5.575   1.532    8.639    104.6   5.0              5.640
                                                                                    2.612
  9   160.2     86.6    73.6    111.1     7.230   1.646   10.522    138.1   6.7              8.251
                                                                                   -1.405
 10    79.7     43.3    36.4     55.4     6.462   1.274    9.010     37.0   5.8              6.847
                                                                                    0.007
 11    79.6     43.3    36.3     55.4     6.652   1.108    8.867     37.0   5.9              6.854
                                                                                    0.001
 12    74.7     44.0    30.7     54.2     6.654   1.106    8.867     33.6   6.0              6.855
                                                                                    0.0
 13    69.0     44.3    24.7     52.5     6.654   1.106    8.867     30.3   6.0              6.855
                                                                                   -0.002
 14    64.7     46.0    18.7     52.2     6.646   1.111    8.867     29.9   5.9              6.853
                                                                                   -0.004
 15    60.3     47.6    12.7     51.8     6.622   1.122    8.867     30.2   5.9              6.849
                                                                                   -0.003
 16    56.1     49.4     6.7     51.6     6.587   1.140    8.867     31.5   5.9              6.846
                                                                                   -0.001
 17    51.5     51.5     0.0     51.5     6.543   1.162    8.867     34.0   5.9              6.844
                                                                                   -0.000
 18    51.1     51.1     0.0     51.1     6.524   1.171    8.867     33.4   5.8              6.844
                                                                                   -0.000
 19    51.0     51.0     0.0     51.0     6.453   1.207    8.867     33.2   5.8              6.844
```

```
                                                                                  -0.000
20    51.0     51.0     0.0     51.0     6.402    1.232    6.867    33.2    5.7              6.844
                                                                                  -0.000
21    50.9     50.9     0.0     50.9     6.334    1.287    6.867    33.1    5.7              6.844
                                                                                  -0.000
22    50.9     50.9     0.0     50.9     6.194    1.336    6.867    33.1    5.6              6.844
                                                                                  -0.000
23    50.8     50.8     0.0     50.8     6.158    1.354    6.867    33.0    5.5              6.844
                                                                                  -0.000
24    50.4     50.4     0.0     50.4     6.130    1.353    6.867    32.4    5.5              6.844
                                                                                  -0.000
25    51.2     51.2     0.0     51.2     6.112    1.377    6.867    33.5    5.5              6.844
                                                                                  -0.000
26    51.5     51.5     0.0     51.5     6.052    1.407    6.867    34.0    5.5              6.844
                                                                                  -0.000
27    42.4     42.4     0.0     42.4     5.987    1.440    6.867    22.5    5.4              6.844
                                                                                  -0.000
28    40.7     40.7     0.0     40.7     5.904    1.481    6.867    21.0    5.3              6.844
                                                                                  -0.000
29    36.0     36.0     0.0     36.0     5.754    1.555    6.867    18.8    5.2              6.844
                                                                                  -0.000
30    33.6     33.6     0.0     33.6     5.708    1.579    6.867    18.7    5.2              6.844
                                                                                  -0.000
31    31.7     31.7     0.0     31.7     5.654    1.608    6.867    18.4    5.2              6.844
                                                                                  -0.000
32    29.7     29.7     0.0     29.7     5.583    1.637    6.867    20.7    5.1              6.844
                                                                                  -0.000
33    30.0     30.0     0.0     30.0     5.550    1.658    6.867    20.5    5.1              6.844
                                                                                  -0.000
34    28.2     28.2     0.0     28.2     5.502    1.682    6.867    21.1    5.0              6.844
```

```
UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

SAMPLE NO. = T 708      (REMOULDED SAMPLE)

SAMPLE HEIGHT AFTER CONSOLIDATION :  11.954 CENTIMETRES
SAMPLE VOLUME AFTER CONSOLIDATION : 527.640 CUBIC CENTIMETRES
SAMPLE AREA AFTER CONSOLIDATION   :  44.139 SQUARE CENTIMETRES

CONSTANT LOAD                     :   16.39  N .
PROVING RING FACTOR               :  1.0225  N ./DIV
PISTON AREA                       :  5.0700 SQUARE CENTIMETRES

INITIAL DIAL READING              : 1847.90 DIVISIONS


SHEAR TEST RESULTS    START    241183     END    261183


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      PCSTRN   KPA      KPA      STRESS   KPA      STRESS   EFF SIFMA3
                                                                      KPA               KPA

  1  1015      1849.7    115.2    200.0   -0.02     50.1     48.2      0.9      1.9     48.8     1.039        0.0
  2  1030      1840.5    153.1    202.0    0.06     56.7     46.0      5.3     10.7     49.6     1.232        0.23
  3  1046      1836.5    186.5    204.9    0.10     61.6     43.2      9.2     18.4     49.3     1.426        0.30
  4  1100      1830.4    215.4    207.4    0.15     65.7     40.6     12.5     25.1     49.0     1.618        0.32
  5  1115      1823.9    242.0    208.7    0.20     70.6     39.4     15.6     31.2     49.8     1.792        0.30
  6  1130      1817.7    260.0    209.6    0.25     73.9     38.6     17.7     35.3     50.4     1.916        0.29
  7  1145      1807.9    278.6    211.4    0.33     76.2     36.6     19.8     39.6     49.8     2.083        0.30
  8  1200      1797.9    299.0    215.0    0.42     77.3     33.0     22.2     44.3     47.8     2.343        0.35
  9  1215      1788.9    313.2    215.7    0.49     79.9     32.4     23.8     47.5     48.2     2.467        0.34
 10  1230      1780.9    325.6    216.8    0.56     81.6     31.2     25.2     50.4     48.0     2.615        0.35
 11  1245      1774.0    339.0    215.4    0.62     86.0     32.6     26.7     53.4     50.4     2.639        0.30
 12  1300      1767.7    351.2    216.6    0.67     87.6     31.4     28.1     56.2     50.1     2.790        0.31
 13  1315      1758.3    357.0    217.3    0.75     88.3     30.8     28.7     57.5     50.0     2.866        0.31
 14  1330      1751.3    369.4    217.5    0.81     90.8     30.5     30.2     60.3     50.6     2.977        0.30
 15  1345      1745.5    374.5    217.1    0.86     92.4     30.9     30.7     61.5     51.4     2.989        0.29
 16  1400      1734.7    383.1    217.7    0.95     93.8     30.4     31.7     63.4     51.5     3.084        0.29
 17  1415      1721.9    388.2    217.4    1.05     95.1     30.6     32.2     64.5     52.1     3.107        0.28
 18  1430      1706.7    393.1    217.4    1.18     96.1     30.6     32.8     65.5     52.4     3.141        0.27
 19  1445      1692.0    397.9    217.3    1.30     97.2     30.7     33.3     66.5     52.9     3.167        0.27
 20  1500      1681.1    405.0    217.6    1.40     98.5     30.4     34.0     68.1     53.1     3.240        0.27
 21  1515      1668.6    403.0    217.5    1.50     98.1     30.5     33.8     67.6     53.0     3.215        0.27
 22  1533      1657.6    404.0    217.2    1.59     98.6     30.9     33.9     67.7     53.5     3.191        0.26
 23  1600      1634.1    409.0    216.5    1.79    100.4     31.7     34.4     68.7     54.6     3.167        0.25
 24  1630      1607.0    411.5    216.6    2.02    100.8     31.7     34.6     69.1     54.7     3.180        0.25
 25  1700      1571.0    417.8    216.4    2.32    102.4     32.1     35.1     70.3     55.5     3.190        0.24
 26  1730      1546.6    421.7    214.4    2.52    104.8     33.7     35.5     71.1     57.4     3.109        0.21

------------------------------------------------------------------------------------------------------------------------

 27  1800      1519.6    424.5    215.0    2.75    104.6     33.1     35.8     71.5     56.9     3.161        0.22
 28  1830      1495.0    425.0    214.9    2.95    104.8     33.3     35.7     71.5     57.1     3.147        0.21
 29  1859      1468.8    427.2    215.9    3.17    103.9     32.0     35.9     71.9     56.0     3.245        0.23
 30  1901      1466.5    421.8    RELAXATION TEST
 31  1902      1466.2    418.8    RELAXATION TEST
 32  1904      1464.2    415.0    RELAXATION TEST
 33  1909      1462.9    410.0    RELAXATION TEST
 34  1915      1461.1    406.1    RELAXATION TEST
 35  1930      1459.8    401.3    RELAXATION TEST
 36  2000      1458.2    395.8    RELAXATION TEST
 37  2101      1457.1    390.0    RELAXATION TEST
 38   811      1453.2    376.2    RELAXATION TEST
 39   844      1452.8    373.5    RELAXATION TEST
 40   845      1452.8    373.5    214.0    3.31     94.2     34.5     29.8     59.7     54.4     2.729        0.24
 41   856      1449.1    400.0    215.0    3.34     98.9     33.3     32.8     65.6     55.2     2.970        0.24
 42   908      1442.6    418.8    215.8    3.39    102.3     32.5     34.9     69.8     55.8     3.147        0.23
 43   928      1428.8    430.8    216.0    3.51    104.6     32.2     36.2     72.4     56.3     3.248        0.23
 44   945      1413.0    435.0    215.0    3.64    106.2     33.0     36.6     73.2     57.4     3.219        0.21
 45  1000      1408.8    437.3    214.0    3.67    107.7     34.0     36.9     73.7     58.6     3.168        0.19
 46  1015      1384.0    439.1    213.1    3.88    108.9     34.9     37.0     74.0     59.6     3.119        0.18
 47  1030      1369.5    439.2    213.6    4.00    108.4     34.5     36.9     73.9     59.1     3.142        0.19
 48  1045      1348.8    442.2    214.0    4.18    108.4     34.0     37.2     74.4     58.8     3.189        0.19
 49  1100      1333.9    440.5    213.7    4.30    108.3     34.3     37.0     74.0     59.0     3.156        0.19
 50  1130      1306.4    439.2    214.1    4.53    107.7     34.2     36.7     73.5     58.7     3.148        0.20
 51  1230      1248.6    438.2    214.0    5.01    107.1     34.2     36.4     72.9     58.5     3.131        0.20
 52  1300      1221.6    438.8    214.4    5.24    106.5     33.7     36.4     72.8     58.0     3.161        0.20
 53  1330      1194.6    439.8    214.2    5.47    106.9     34.0     36.4     72.9     58.3     3.143        0.20
 54  1400      1163.2    439.2    215.0    5.73    105.7     33.2     36.3     72.5     57.4     3.185        0.21
 55  1502      1101.1    441.8    215.2    6.25    105.6     32.9     36.4     72.7     57.1     3.210        0.21
 56  1529      1076.2    443.5    213.1    6.46    107.7     34.8     36.5     72.9     59.1     3.096        0.18
 57  1600      1049.7    451.9    211.0    6.68    111.6     37.0     37.3     74.6     61.9     3.016        0.15
 58  1630      1023.2    454.5    209.5    6.90    113.6     38.6     37.5     75.0     63.6     2.942        0.13
 59  1655      1000.0    459.7    208.0    7.09    115.9     40.0     38.0     75.9     65.3     2.898        0.11
 60   905        86.2    470.2    215.2   14.74    104.6     32.9     35.9     71.7     56.8     3.181        0.22
 61   935        61.0    472.1    214.3   14.95    105.7     33.7     36.0     72.0     57.7     3.135        0.20
```

```
UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

SAMPLE NO. : T 708      (REMOULDED SAMPLE)

CONSOLIDATION AXIAL STRESS        :   48.00 KPA
PRECONSOLIDATION PRESSURE         :  160.20 KPA
NORMALIZING STRESS                :  160.20 KPA

NORMALIZED SHEAR TEST RESULTS    START    241183     END    261183

  PT     PER        NRMLZD     EFFECT    NRMLZD     NRMLZD
         CENT       HALF       RATIO     OCT        CHANGE
         PCSTRN     DEV        SIGMA1    STRESS     IN PWP
                    STRESS     SIGMA3    KPA        KPA
                    KPA

   1    -0.02       0.006      1.039     0.305      0.0
   2     0.06       0.033      1.232     0.309      0.012
   3     0.10       0.057      1.426     0.308      0.031
   4     0.15       0.078      1.618     0.306      0.046
   5     0.20       0.097      1.792     0.311      0.054
   6     0.25       0.110      1.916     0.314      0.060
   7     0.33       0.124      2.083     0.311      0.071
   8     0.42       0.138      2.343     0.298      0.094
   9     0.49       0.148      2.467     0.301      0.098
  10     0.56       0.157      2.615     0.300      0.105
  11     0.62       0.167      2.639     0.315      0.096
  12     0.67       0.175      2.790     0.313      0.104
  13     0.75       0.179      2.866     0.312      0.108
  14     0.81       0.188      2.977     0.316      0.109
  15     0.86       0.192      2.989     0.321      0.107
  16     0.95       0.198      3.084     0.322      0.110
  17     1.05       0.201      3.107     0.325      0.109
  18     1.18       0.204      3.141     0.327      0.109
  19     1.30       0.208      3.167     0.330      0.108
  20     1.40       0.213      3.240     0.331      0.110
  21     1.50       0.211      3.215     0.331      0.109
  22     1.59       0.211      3.191     0.334      0.107
  23     1.79       0.214      3.167     0.341      0.103
  24     2.02       0.216      3.180     0.342      0.104
  25     2.32       0.219      3.190     0.347      0.102
  26     2.52       0.222      3.109     0.358      0.090
  27     2.75       0.223      3.161     0.355      0.094
  28     2.95       0.223      3.147     0.357      0.093
  29     3.17       0.224      3.245     0.349      0.099
  40     3.31       0.186      2.729     0.339      0.087
  41     3.34       0.205      2.970     0.344      0.094
  42     3.39       0.218      3.147     0.348      0.099
  43     3.51       0.226      3.248     0.352      0.100
  44     3.64       0.229      3.219     0.358      0.094
  45     3.67       0.230      3.168     0.366      0.087
  46     3.88       0.231      3.119     0.372      0.082
------------------------------------------------------------------------------------------------------------------

  47     4.00       0.231      3.142     0.369      0.085
  48     4.18       0.232      3.189     0.367      0.087
  49     4.30       0.231      3.156     0.368      0.086
  50     4.53       0.229      3.148     0.366      0.088
  51     5.01       0.227      3.131     0.365      0.087
  52     5.24       0.227      3.161     0.362      0.090
  53     5.47       0.227      3.143     0.364      0.089
  54     5.73       0.226      3.185     0.358      0.094
  55     6.25       0.227      3.210     0.357      0.095
  56     6.46       0.228      3.096     0.369      0.082
  57     6.68       0.233      3.016     0.386      0.069
  58     6.90       0.234      2.942     0.397      0.059
  59     7.09       0.237      2.898     0.408      0.050
  60    14.74       0.224      3.181     0.355      0.095
  61    14.95       0.225      3.135     0.360      0.089
```

```
UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

SAMPLE NO. : T 710     (REMOULDED SAMPLE)
INITIAL MOISTURE CONTENT            :   46.2 PERCENT
SPECIFIC GRAVITY OF SOIL            :  2.73
INITIAL VOID RATIO                  :   1.260
INITIAL HEIGHT OF SAMPLE            :  12.78 CM
INITIAL VOLUME OF SAMPLE            :  579.76 CC
EFFECTIVE PRINCIPAL STRESS RATIO    :  1.00
FINAL MOISTURE CONTENT              :   38.2 PERCENT

TX.  CONSOLIDATION    START     61283     END    201283
TRIAXIAL CONSOLIDATION TEST
:::::::::::::::::::::::::::



  PT  EFFECT   EFFECT  STRAIN1   VOLUME  STRAIN3   EFFECT      Q       VOID       V       SHEAR
      SIGMA1   SIGMA3            STRAIN               P                RATIO              STRAIN

   1   50.19    27.00    1.582    2.346    0.382    34.73    23.19    1.207    2.207    0.800
   2   57.59    31.05    1.915    2.962    0.523    39.90    26.54    1.193    2.193    0.928
   3   66.36    35.70    2.357    3.695    0.669    45.92    30.66    1.177    2.177    1.125
   4   76.43    41.20    2.936    4.519    0.792    52.94    35.23    1.158    2.158    1.429
   5   87.86    47.40    3.739    5.623    0.942    60.89    40.46    1.133    2.133    1.864
   6  101.15    53.50    4.768    6.865    1.048    69.38    47.65    1.105    2.105    2.480
   7  116.36    61.60    5.862    8.193    1.165    79.85    54.76    1.075    2.075    3.131
   8  133.99    70.90    6.906    9.418    1.256    91.93    63.09    1.047    2.047    3.767
   9  160.07    84.80    8.470   11.039    1.284   109.89    75.27    1.011    2.011    4.791
  10   79.73    42.40    7.700    9.694    0.997    54.84    37.33    1.041    2.041    4.468
  11   79.65    42.40    7.829    9.607    0.889    54.82    37.25    1.043    2.043    4.627
  12   74.90    43.50    7.829    9.607    0.889    53.97    31.40    1.043    2.043    4.627
  13   71.30    46.20    7.818    9.607    0.895    54.57    25.10    1.043    2.043    4.615
  14   67.20    48.40    7.800    9.607    0.904    54.67    18.80    1.043    2.043    4.597
  15   63.30    50.80    7.757    9.607    0.925    54.97    12.50    1.043    2.043    4.554
  16   59.20    53.00    7.721    9.607    0.943    55.07     6.20    1.043    2.043    4.519
  17   55.70    55.70    7.582    9.607    1.013    55.70     0.0     1.043    2.043    4.380
  18   54.50    54.50    7.551    9.607    1.028    54.50     0.0     1.043    2.043    4.348
  19   52.40    52.40    7.510    9.607    1.049    52.40     0.0     1.043    2.043    4.308
  20   50.20    50.20    7.454    9.607    1.077    50.20     0.0     1.043    2.043    4.251
  21   46.00    46.00    7.426    9.607    1.091    46.00     0.0     1.043    2.043    4.223
  22   42.10    42.10    7.423    9.607    1.092    42.10     0.0     1.043    2.043    4.220
  23   37.90    37.90    7.407    9.607    1.100    37.90     0.0     1.043    2.043    4.204
  24   33.50    33.50    7.405    9.607    1.101    33.50     0.0     1.043    2.043    4.202
  25   30.20    30.20    7.397    9.607    1.105    30.20     0.0     1.043    2.043    4.194
  26   27.80    27.80    7.397    9.607    1.105    27.80     0.0     1.043    2.043    4.194
  27   25.80    25.80    7.394    9.607    1.107    25.80     0.0     1.043    2.043    4.192
  28   24.10    24.10    7.383    9.607    1.112    24.10     0.0     1.043    2.043    4.180
  29   24.80    24.80    7.381    9.607    1.113    24.80     0.0     1.043    2.043    4.179
--------------------------------------------------------------------------------------------------------
  30   24.30    24.30    7.383    9.607    1.112    24.30     0.0     1.043    2.043    4.180
  31   22.80    22.80    7.346    9.607    1.131    22.80     0.0     1.043    2.043    4.143
  32   23.80    23.80    7.308    9.607    1.150    23.80     0.0     1.043    2.043    4.106
```

```
SUMMARY OF ESSENTIAL RESULTS STORED IN FILE


  PT   SIGMA1    SIGMA3    STRAIN1    STRAIN3      V

   1    50.18     27.00     1.562      0.382     2.207
   2    57.58     31.05     1.815      0.523     2.193
   3    66.38     35.70     2.357      0.669     2.177
   4    76.43     41.20     2.936      0.792     2.156
   5    87.88     47.40     3.739      0.942     2.133
   6   101.15     53.50     4.786      1.048     2.105
   7   116.36     61.80     5.882      1.165     2.075
   8   133.98     70.90     6.906      1.256     2.047
   9   160.07     84.80     8.470      1.284     2.011
  10    79.73     42.40     7.700      0.897     2.041
  11    79.65     42.40     7.829      0.869     2.043
  12    74.90     43.50     7.829      0.869     2.043
  13    71.30     46.20     7.816      0.885     2.043
  14    67.20     48.40     7.800      0.904     2.043
  15    63.30     50.80     7.757      0.925     2.043
  16    59.20     53.00     7.721      0.943     2.043
  17    55.70     55.70     7.582      1.013     2.043
  18    54.50     54.50     7.551      1.028     2.043
  19    52.40     52.40     7.510      1.049     2.043
  20    50.20     50.20     7.454      1.077     2.043
  21    46.00     46.00     7.426      1.081     2.043
  22    42.10     42.10     7.423      1.092     2.043
  23    37.90     37.90     7.407      1.100     2.043
  24    33.50     33.50     7.405      1.101     2.043
  25    30.20     30.20     7.397      1.105     2.043
  26    27.80     27.80     7.397      1.105     2.043
  27    25.80     25.80     7.394      1.107     2.043
  28    24.10     24.10     7.383      1.112     2.043
  29    24.80     24.80     7.381      1.113     2.043
  30    24.30     24.30     7.383      1.112     2.043
  31    22.80     22.80     7.346      1.131     2.043
  32    23.80     23.80     7.306      1.150     2.043
```

```
UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

ENERGY CALCULATIONS

****  ENGINEERING STRAIN  ****

SAMPLE NO. : T 710      (REMOULDED SAMPLE)
TEST RESULTS     START      61283     END     201283


 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     50.2      27.0     23.2      34.7      1.562    0.382     2.348      0.0     0.0                0.0
                                                                                             0.262
  2     57.6      31.1     26.5      39.9      1.815    0.523     2.962      9.4     0.4                0.262
                                                                                             0.371
  3     66.4      35.7     30.7      45.9      2.357    0.669     3.685     20.3     0.9                0.632
                                                                                             0.508
  4     76.4      41.2     35.2      52.9      2.936    0.792     4.519     33.0     1.5                1.140
                                                                                             0.793
  5     87.9      47.4     40.5      60.9      3.739    0.942     5.623     47.4     2.3                1.933
                                                                                             1.080
  6    101.1      53.5     47.6      69.4      4.786    1.048     6.885     63.3     3.3                3.013
                                                                                             1.324
  7    116.4      61.8     54.6      79.9      5.882    1.165     8.193     82.3     4.4                4.338
                                                                                             1.426
  8    134.0      70.9     63.1      91.9      6.906    1.256     9.418    104.3     5.5                5.764
                                                                                             2.344
  9    160.1      84.8     75.3     109.9      8.470    1.284    11.039    136.9     7.0                8.108
                                                                                            -1.289
 10     79.7      42.4     37.3      54.8      7.700    0.897     9.684     38.7     6.2                6.819
                                                                                             0.012
 11     79.6      42.4     37.3      54.8      7.829    0.869     9.607     36.6     6.3                6.831
                                                                                             0.0
 12     74.9      43.5     31.4      54.0      7.829    0.869     9.607     34.0     6.3                6.831
                                                                                            -0.003
 13     71.3      46.2     25.1      54.6      7.816    0.885     9.607     34.4     6.3                6.827
                                                                                            -0.004
 14     67.2      48.4     18.8      54.7      7.800    0.904     9.607     34.7     6.3                6.823
                                                                                            -0.007
 15     63.3      50.8     12.5      55.0      7.757    0.925     9.607     36.1     6.2                6.817
                                                                                            -0.003
 16     59.2      53.0      6.2      55.1      7.721    0.943     9.607     37.9     6.2                6.813
                                                                                            -0.004
 17     55.7      55.7      0.0      55.7      7.582    1.013     9.607     41.0     6.1                6.809
                                                                                             0.0
 18     54.5      54.5      0.0      54.5      7.551    1.028     9.607     39.1     6.0                6.809
                                                                                            -0.000
 19     52.4      52.4      0.0      52.4      7.510    1.049     9.607     38.0     6.0                6.809
```

										0.000	
20	50.2	50.2	0.0	50.2	7.454	1.077	9.607	32.8	6.0		6.608
										0.0	
21	46.0	46.0	0.0	46.0	7.426	1.091	9.607	27.2	5.8		6.608
										-0.000	
22	42.1	42.1	0.0	42.1	7.423	1.092	9.607	22.8	5.8		6.608
										0.0	
23	37.9	37.9	0.0	37.9	7.407	1.100	9.607	18.7	5.9		6.608
										0.000	
24	33.5	33.5	0.0	33.5	7.405	1.101	9.607	19.1	5.8		6.608
										0.0	
25	30.2	30.2	0.0	30.2	7.397	1.105	9.607	20.5	5.8		6.608
										0.0	
26	27.6	27.6	0.0	27.6	7.397	1.105	9.607	22.4	5.8		6.608
										0.0	
27	25.8	25.8	0.0	25.8	7.394	1.107	9.607	24.4	5.9		6.608
										-0.000	
28	24.1	24.1	0.0	24.1	7.383	1.112	9.607	26.4	5.9		6.609
										0.000	
29	24.6	24.6	0.0	24.6	7.381	1.113	9.607	25.6	5.9		6.609
										-0.000	
30	24.3	24.3	0.0	24.3	7.383	1.112	9.607	26.2	5.9		6.609
										0.0	
31	22.8	22.8	0.0	22.8	7.346	1.131	9.607	28.0	5.8		6.608
										0.000	
32	23.6	23.6	0.0	23.6	7.308	1.150	9.607	28.8	5.8		6.608

UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

ENERGY CALCULATIONS

****   NATURAL STRAIN   ****

SAMPLE NO. = T 710   (REMOULDED SAMPLE)
TEST RESULTS   START   81283   END   201283

PT	EFFECT SIGMA1 KPA	EFFECT SIGMA3 KPA	DEV STRESS KPA	EFFECT OCT STRESS KPA	AXIAL STRAIN %	RADIAL STRAIN %	VOL STRAIN %	LSSV KPA	LSNV %	DELTA ENERGY KN-M/VOL	TOTAL ENERGY KN-M/VOL
1	50.2	27.0	23.2	34.7	1.595	0.389	2.374	0.0	0.0		0.0
										0.268	
2	57.6	31.1	26.5	39.9	1.934	0.536	3.006	9.4	0.4		0.268
										0.382	
3	66.4	35.7	30.7	45.9	2.385	0.690	3.764	20.3	0.9		0.650
										0.527	
4	76.4	41.2	35.2	52.9	2.980	0.822	4.624	33.0	1.5		1.177
										0.829	
5	87.9	47.4	40.5	60.9	3.810	0.988	5.787	47.4	2.4		2.006
										1.142	
6	101.1	53.5	47.6	69.4	4.886	1.113	7.112	63.3	3.4		3.148
										1.418	
7	116.4	61.6	54.8	79.9	6.041	1.253	8.546	82.3	4.6		4.566
										1.547	
8	134.0	70.9	63.1	91.9	7.156	1.367	9.891	104.3	5.7		6.113
										2.578	
9	160.1	84.8	75.3	109.9	8.851	1.423	11.697	136.9	7.4		8.691
										-1.427	
10	79.7	42.4	37.3	54.8	8.012	1.092	10.196	36.7	6.5		7.264
										0.012	
11	79.6	42.4	37.3	54.8	8.153	0.974	10.101	36.6	6.6		7.276
										0.0	
12	74.9	43.5	31.4	54.0	8.153	0.974	10.101	34.0	6.6		7.276
										-0.004	
13	71.3	46.2	25.1	54.6	8.140	0.980	10.101	34.4	6.6		7.273
										-0.004	
14	67.2	48.4	18.8	54.7	8.121	0.990	10.101	34.7	6.6		7.269
										-0.007	
15	63.3	50.8	12.5	55.0	8.074	1.013	10.101	36.1	6.5		7.261
										-0.004	
16	59.2	53.0	6.2	55.1	8.036	1.032	10.101	37.9	6.5		7.258
										-0.005	
17	55.7	55.7	0.0	55.7	7.885	1.108	10.101	41.0	6.4		7.253
										-0.000	
18	54.5	54.5	0.0	54.5	7.851	1.125	10.101	39.1	6.3		7.253
										-0.000	
19	52.4	52.4	0.0	52.4	7.807	1.147	10.101	38.0	6.3		7.253

```
                                                                          -0.000
20   50.2   50.2   0.0   50.2   7.748   1.177   10.101   32.8   6.3             7.253
                                                                          -0.000
21   46.0   46.0   0.0   46.0   7.716   1.182   10.101   27.2   6.2             7.253
                                                                          -0.000
22   42.1   42.1   0.0   42.1   7.712   1.184   10.101   22.8   6.2             7.253
                                                                          -0.000
23   37.9   37.9   0.0   37.9   7.685   1.203   10.101   19.7   6.2             7.253
                                                                          -0.000
24   33.5   33.5   0.0   33.5   7.693   1.204   10.101   18.1   6.2             7.253
                                                                          -0.000
25   30.2   30.2   0.0   30.2   7.684   1.206   10.101   20.5   6.2             7.253
                                                                           0.0
26   27.8   27.8   0.0   27.8   7.684   1.208   10.101   22.4   6.2             7.253
                                                                          -0.000
27   25.8   25.8   0.0   25.8   7.582   1.209   10.101   24.4   6.2             7.253
                                                                          -0.000
28   24.1   24.1   0.0   24.1   7.669   1.216   10.101   26.4   6.2             7.253
                                                                          -0.000
29   24.6   24.6   0.0   24.6   7.668   1.217   10.101   25.6   6.2             7.253
                                                                          -0.000
30   24.3   24.3   0.0   24.3   7.669   1.218   10.101   28.2   6.2             7.253
                                                                          -0.000
31   22.6   22.6   0.0   22.6   7.630   1.236   10.101   28.0   6.2             7.253
                                                                          -0.000
32   23.6   23.6   0.0   23.6   7.569   1.255   10.101   26.8   6.1             7.253
```

```
UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

SAMPLE NO. : T 710     (REMOULDED SAMPLE)

SAMPLE HEIGHT AFTER CONSOLIDATION :   11.821 CENTIMETRES
SAMPLE VOLUME AFTER CONSOLIDATION : 518.160 CUBIC CENTIMETRES
SAMPLE AREA AFTER CONSOLIDATION   :   43.834 SQUARE CENTIMETRES

CONSTANT LOAD                     :    16.55  N .
PROVING RING FACTOR               :   1.2365  N ./DIV
PISTON AREA                       :   5.0700 SQUARE CENTIMETRES

INITIAL DIAL READING              : 1599.80 DIVISIONS


SHEAR TEST RESULTS    START    211283      END     231283


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     PCSTRN  KPA      KPA      STRESS   KPA      STRESS   EFF SIFMA3
                                                                 KPA               KPA

  1   821    1599.8   105.8   199.9   0.0       81.4     80.2      0.6      1.2     80.6     1.015        0.0
  2   825    1598.0   106.0   187.0   0.02      94.4     93.1      0.6      1.3     93.5     1.014     -229.73
  3   831    1592.8   110.0   183.8   0.06      98.7     96.3      1.2      2.4     97.1     1.025      -13.61
  4   840    1586.2   123.8   184.0   0.12     102.4     96.1      3.1      6.3     98.2     1.065       -3.14
  5   850    1582.6   144.5   187.5   0.15     104.6     92.5      6.1     12.1     96.5     1.131       -1.14
  6   900    1578.5   164.0   190.8   0.18     106.9     89.3      8.8     17.6     95.2     1.197       -0.56
  7   915    1571.8   191.5   194.0   0.24     111.2     85.8     12.7     25.4     94.3     1.296       -0.24
  8   930    1564.8   218.0   198.0   0.30     114.8     82.0     16.4     32.8     92.9     1.400       -0.06
  9   945    1557.0   242.5   199.8   0.36     119.7     80.0     19.8     39.7     93.2     1.496       -0.00
 10  1000    1549.0   264.0   202.1   0.43     123.7     78.0     22.8     45.7     93.2     1.585        0.05
 11  1015    1540.0   286.0   204.3   0.51     127.3     75.5     25.9     51.8     92.8     1.686        0.09
 12  1030    1531.8   306.2   206.1   0.58     131.3     73.9     28.7     57.4     93.0     1.777        0.11
 13  1045    1523.2   324.5   207.9   0.65     134.4     71.9     31.3     62.5     92.7     1.870        0.13
 14  1100    1514.2   342.5   209.2   0.72     138.3     70.8     33.8     67.5     93.3     1.954        0.14
 15  1115    1504.0   359.5   210.2   0.81     141.7     69.5     36.1     72.2     93.6     2.039        0.15
 16  1130    1493.3   374.5   210.8   0.90     145.4     69.1     38.2     76.3     94.5     2.105        0.15
 17  1145    1482.8   388.5   211.7   0.99     148.4     68.2     40.1     80.2     94.9     2.176        0.15
 18  1200    1472.5   399.6   212.4   1.08     150.7     67.5     41.6     83.2     95.2     2.233        0.15
 19  1215    1460.8   409.0   213.0   1.18     152.4     66.6     42.9     85.8     95.2     2.288        0.15
 20  1230    1448.5   416.8   214.1   1.28     153.6     65.8     43.9     87.8     95.1     2.335        0.16
 21  1245    1435.5   424.0   214.2   1.39     155.4     65.7     44.9     89.7     95.6     2.366        0.16
 22  1300    1423.4   428.2   214.7   1.49     156.0     65.2     45.4     90.8     95.5     2.393        0.17
 23  1315    1410.2   432.8   214.5   1.60     157.1     65.1     46.0     92.0     95.8     2.414        0.16
 24  1331    1396.4   436.4   215.3   1.72     157.4     64.5     46.4     92.9     95.5     2.440        0.17
 25  1345    1384.5   439.5   215.8   1.82     157.7     64.0     46.8     93.7     95.2     2.463        0.17
 26  1400    1370.9   442.0   216.5   1.94     157.5     63.3     47.1     94.2     94.7     2.489        0.18
-----------------------------------------------------------------------------------------------------------------

 27  1415    1356.8   444.0   216.4   2.06     157.8     63.1     47.4     94.7     94.7     2.501        0.18
 28  1430    1344.4   446.4   217.3   2.16     157.7     62.5     47.6     95.2     94.2     2.524        0.19
 29  1445    1330.0   447.6   217.4   2.28     157.8     62.3     47.7     95.5     94.1     2.532        0.19
 30  1500    1316.0   449.7   217.6   2.40     158.1     62.2     48.0     95.9     94.2     2.542        0.19
 31  1520    1297.9   451.5   217.8   2.55     158.4     62.2     48.1     96.2     94.3     2.547        0.19
 32  1540    1280.4   453.5   217.7   2.70     159.1     62.5     48.3     96.6     94.7     2.546        0.19
 33  1559    1262.4   456.2   217.7   2.85     159.3     62.1     48.6     97.2     94.5     2.566        0.19
 34  1600    1262.4   456.2   RELAXATION TEST
 35  1601    1260.5   455.0   RELAXATION TEST
 36  1602    1260.2   452.0   RELAXATION TEST
 37  1604    1259.7   449.3   RELAXATION TEST
 38  1608    1258.4   445.0   RELAXATION TEST
 39  1615    1257.0   439.5   RELAXATION TEST
 40  1630    1255.4   432.5   RELAXATION TEST
 41  1650    1253.4   426.0   RELAXATION TEST
 42  2127    1246.8   409.0   RELAXATION TEST
 43   819    1240.0   374.0   RELAXATION TEST
 44   820    1240.0   374.0   207.8   3.04     146.9     72.4     37.3     74.5     97.2     2.029        0.11
 45   830    1236.8   397.0   199.9   3.07     161.1     80.3     40.4     80.8    107.2     2.006        0.0
 46   840    1232.6   418.8   200.6   3.11     166.3     79.6     43.4     86.7    108.5     2.090        0.01
 47   850    1227.9   437.0   201.5   3.15     170.1     78.4     45.8     91.7    109.0     2.170        0.02
 48   900    1222.8   451.2   202.5   3.19     173.2     77.7     47.7     95.5    109.5     2.229        0.03
 49   910    1216.3   462.5   203.3   3.24     175.4     76.9     49.3     98.5    109.7     2.281        0.03
 50   920    1209.0   472.0   204.1   3.31     177.2     76.1     50.5    101.1    109.8     2.328        0.04
 51   930    1200.7   477.2   204.7   3.38     177.9     75.5     51.2    102.4    109.6     2.356        0.05
 52   945    1188.0   484.2   205.8   3.48     178.6     74.4     52.1    104.2    109.1     2.400        0.06
 53  1000    1175.6   487.2   209.8   3.59     175.3     70.4     52.4    104.9    105.4     2.490        0.10
 54  1015    1160.7   489.0   212.6   3.71     172.6     67.3     52.6    105.3    102.4     2.564        0.12
 55  1030    1148.1   489.8   214.6   3.82     170.9     65.6     52.7    105.3    100.7     2.606        0.14
 56  1050    1129.0   490.0   216.2   3.98     169.0     63.8     52.6    105.2     98.9     2.650        0.16
 57  1108    1112.0   490.0   217.5   4.13     167.7     62.6     52.5    105.1     97.6     2.679        0.17
 58  1210    1055.1   490.0   221.0   4.61     163.7     59.1     52.3    104.6     94.0     2.769        0.20
 59  1315     995.1   489.2   223.1   5.12     160.7     56.9     51.9    103.8     91.5     2.824        0.23
 60  1402     948.8   488.5   224.1   5.51     159.2     56.0     51.6    103.2     90.4     2.842        0.24
 61  1505     889.2   488.5   225.6   6.01     157.1     54.5     51.3    102.6     88.7     2.883        0.25
 62  1600     850.0   488.5   226.8   6.34     155.6     53.3     51.1    102.3     87.4     2.918        0.27
 63  1650     790.4   487.9   227.1   6.85     154.5     53.0     50.8    101.5     86.8     2.916        0.27
 64  2222     482.8   486.5   231.2   9.45     147.4     49.1     49.2     98.3     81.9     3.003        0.32
 65   803     -66.0   479.5   232.6  14.09     139.1     47.5     45.8     91.6     78.0     2.929        0.36
 66   910    -128.2   478.5   233.0  14.62     138.1     47.3     45.4     90.8     77.6     2.919        0.37
 67   940    -157.6   478.5   233.0  14.87     137.7     47.2     45.3     90.5     77.4     2.918        0.37
```

```
UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

SAMPLE NO. = T 710     (REMOULDED SAMPLE)

CONSOLIDATION AXIAL STRESS         =   80.00 KPA
PRECONSOLIDATION PRESSURE          =  160.07 KPA
NORMALIZING STRESS                 =  160.07 KPA


NORMALIZED SHEAR TEST RESULTS    START    211283     END     231283

 PT     PER        NRMLZD     EFFECT    NRMLZD     NRMLZD
        CENT       HALF       RATIO     OCT        CHANGE
        PCSTRN     DEV        SIGMA1    STRESS     IN PWP
                   STRESS     SIGMA3    KPA        KPA
                   KPA

  1     0.0        0.004      1.015     0.504      0.0
  2     0.02       0.004      1.014     0.584     -0.081
  3     0.06       0.008      1.025     0.607     -0.101
  4     0.12       0.020      1.065     0.613     -0.099
  5     0.15       0.038      1.131     0.603     -0.077
  6     0.18       0.055      1.197     0.595     -0.057
  7     0.24       0.079      1.296     0.589     -0.037
  8     0.30       0.102      1.400     0.581     -0.012
  9     0.36       0.124      1.496     0.582     -0.001
 10     0.43       0.143      1.585     0.582      0.014
 11     0.51       0.162      1.686     0.580      0.027
 12     0.58       0.179      1.777     0.581      0.039
 13     0.65       0.195      1.870     0.579      0.050
 14     0.72       0.211      1.954     0.583      0.058
 15     0.81       0.226      2.039     0.585      0.064
 16     0.90       0.238      2.105     0.591      0.068
 17     0.99       0.250      2.176     0.593      0.074
 18     1.08       0.260      2.233     0.595      0.078
 19     1.18       0.268      2.288     0.595      0.082
 20     1.28       0.274      2.335     0.594      0.089
 21     1.39       0.280      2.366     0.597      0.089
 22     1.49       0.284      2.393     0.596      0.092
 23     1.60       0.287      2.414     0.598      0.091
 24     1.72       0.290      2.440     0.596      0.096
 25     1.82       0.293      2.463     0.595      0.099
 26     1.94       0.294      2.489     0.592      0.104
 27     2.06       0.296      2.501     0.591      0.103
 28     2.16       0.297      2.524     0.589      0.109
 29     2.28       0.298      2.532     0.588      0.109
 30     2.40       0.300      2.542     0.588      0.111
 31     2.55       0.301      2.547     0.589      0.112
 32     2.70       0.302      2.546     0.592      0.111
 33     2.85       0.304      2.566     0.590      0.111
 44     3.04       0.233      2.029     0.607      0.049
 45     3.07       0.252      2.006     0.670      0.0
 46     3.11       0.271      2.090     0.678      0.004

---------------------------------------------------------------------------------------------------------------

 47     3.15       0.286      2.170     0.681      0.010
 48     3.19       0.298      2.229     0.684      0.016
 49     3.24       0.308      2.281     0.686      0.021
 50     3.31       0.316      2.328     0.686      0.026
 51     3.38       0.320      2.356     0.685      0.030
 52     3.48       0.325      2.400     0.682      0.037
 53     3.59       0.328      2.490     0.658      0.062
 54     3.71       0.329      2.564     0.640      0.079
 55     3.82       0.329      2.606     0.629      0.092
 56     3.98       0.329      2.650     0.618      0.102
 57     4.13       0.328      2.679     0.610      0.110
 58     4.61       0.327      2.769     0.587      0.132
 59     5.12       0.324      2.824     0.572      0.145
 60     5.51       0.322      2.842     0.565      0.151
 61     6.01       0.321      2.883     0.554      0.161
 62     6.34       0.319      2.918     0.546      0.168
 63     6.85       0.317      2.916     0.543      0.170
 64     9.45       0.307      3.003     0.512      0.196
 65    14.09       0.286      2.929     0.488      0.204
 66    14.62       0.284      2.919     0.485      0.207
 67    14.87       0.283      2.918     0.483      0.207
```

```
UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

SAMPLE NO. : T 712      (REMOULDED SAMPLE)
INITIAL MOISTURE CONTENT             :   47.4 PERCENT
SPECIFIC GRAVITY OF SOIL             :  2.73
INITIAL VOID RATIO                   :   1.295
INITIAL HEIGHT OF SAMPLE             :  12.59 CM
INITIAL VOLUME OF SAMPLE             :  571.06 CC
EFFECTIVE PRINCIPAL STRESS RATIO     :  1.00
FINAL MOISTURE CONTENT               :   38.8 PERCENT

TX.  CONSOLIDATION    START    161183     END      11283
TRIAXIAL CONSOLIDATION TEST
:::::::::::::::::::::::::::



 PT  EFFECT    EFFECT   STRAIN1    VOLUME  STRAIN3    EFFECT       Q        VOID       V       SHEAR
     SIGMA1    SIGMA3              STRAIN                P                  RATIO              STRAIN

  1   50.28     25.00     0.850     1.804    0.477     33.43     25.28     1.254     2.254     0.249
  2   57.80     28.90     1.072     2.163    0.545     38.53     28.90     1.246     2.246     0.352
  3   66.52     31.90     1.629     2.872    0.622     43.44     34.62     1.229     2.229     0.671
  4   76.50     35.90     2.623     3.940    0.658     49.43     40.60     1.205     2.205     1.310
  5   87.80     40.40     3.964     5.087    0.562     56.20     47.40     1.178     2.178     2.268
  6  101.02     47.00     5.500     6.689    0.594     65.01     54.02     1.142     2.142     3.271
  7  116.06     53.65     6.840     8.038    0.599     74.45     62.41     1.111     2.111     4.161
  8  133.50     61.70     8.329     9.456    0.563     85.63     71.80     1.078     2.078     5.177
  9  159.89     73.90    10.486    11.531    0.523    102.56     85.99     1.031     2.031     6.642
 10   79.75     37.00     9.730    10.209    0.240     51.25     42.75     1.061     2.061     6.327
 11   79.71     37.00     9.890    10.270    0.190     51.24     42.71     1.059     2.059     6.467
 12   74.00     38.20     9.890    10.270    0.190     50.13     35.80     1.059     2.059     6.467
 13   69.20     40.60     9.885    10.270    0.193     50.13     28.60     1.059     2.059     6.461
 14   64.10     42.70     9.865    10.270    0.203     49.83     21.40     1.059     2.059     6.441
 15   59.20     45.00     9.826    10.270    0.222     49.73     14.20     1.059     2.059     6.402
 16   54.20     47.20     9.791    10.270    0.240     49.53      7.00     1.059     2.059     6.367
 17   50.00     50.00     9.711    10.270    0.280     50.00      0.0      1.059     2.059     6.287
 18   50.20     50.20     9.682    10.270    0.294     50.20      0.0      1.059     2.059     6.259
 19   50.40     50.40     9.633    10.270    0.319     50.40      0.0      1.059     2.059     6.208
 20   49.40     49.40     9.600    10.270    0.335     49.40      0.0      1.059     2.059     6.177
 21   48.70     48.70     9.552    10.270    0.359     48.70      0.0      1.059     2.059     6.128
 22   48.00     48.00     9.523    10.270    0.374     48.00      0.0      1.059     2.059     6.100
 23   46.60     46.60     9.498    10.270    0.386     46.60      0.0      1.059     2.059     6.074
 24   46.70     46.70     9.495    10.270    0.388     46.70      0.0      1.059     2.059     6.071
 25   47.90     47.90     9.474    10.270    0.398     47.90      0.0      1.059     2.059     6.050
 26   47.70     47.70     9.437    10.270    0.416     47.70      0.0      1.059     2.059     6.014
 27   47.80     47.80     9.398    10.270    0.436     47.80      0.0      1.059     2.059     5.974
 28   49.20     49.20     9.352    10.270    0.459     49.20      0.0      1.059     2.059     5.928
```

```
SUMMARY OF ESSENTIAL RESULTS STORED IN FILE



 PT  SIGMA1    SIGMA3    STRAIN1    STRAIN3      V

  1   50.28     25.00     0.850     0.477     2.254
  2   57.80     28.90     1.072     0.545     2.246
  3   66.52     31.90     1.629     0.622     2.229
  4   76.50     35.90     2.623     0.658     2.205
  5   87.80     40.40     3.964     0.562     2.178
  6  101.02     47.00     5.500     0.594     2.142
  7  116.06     53.65     6.840     0.599     2.111
  8  133.50     61.70     8.329     0.563     2.078
  9  159.89     73.90    10.486     0.523     2.031
 10   79.75     37.00     9.730     0.240     2.061
 11   79.71     37.00     9.890     0.190     2.059
 12   74.00     38.20     9.890     0.190     2.059
 13   69.20     40.60     9.885     0.193     2.059
 14   64.10     42.70     9.865     0.203     2.059
 15   59.20     45.00     9.826     0.222     2.059
 16   54.20     47.20     9.791     0.240     2.059
 17   50.00     50.00     9.711     0.280     2.059
 18   50.20     50.20     9.682     0.294     2.059
 19   50.40     50.40     9.633     0.319     2.059
 20   49.40     49.40     9.600     0.335     2.059
 21   48.70     48.70     9.552     0.359     2.059
 22   48.00     48.00     9.523     0.374     2.059
 23   46.60     46.60     9.498     0.386     2.059
 24   46.70     46.70     9.495     0.388     2.059
 25   47.90     47.90     9.474     0.398     2.059
 26   47.70     47.70     9.437     0.416     2.059
 27   47.80     47.80     9.398     0.436     2.059
 28   49.20     49.20     9.352     0.459     2.059
```

```
UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

ENERGY CALCULATIONS

****  ENGINEERING STRAIN  ****

SAMPLE NO. : T 712      (REMOULDED SAMPLE)
TEST RESULTS     START    161183      END      11283


 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     50.3      25.0     25.3       33.4     0.850    0.477     1.804     0.0    0.0                 0.0
                                                                                           0.157
  2     57.8      28.9     28.9       38.5     1.072    0.545     2.163     9.3    0.2                 0.157
                                                                                           0.392
  3     66.5      31.9     34.6       43.4     1.629    0.622     2.872    18.9    0.8                 0.549
                                                                                           0.736
  4     76.5      35.9     40.6       49.4     2.623    0.658     3.940    30.4    1.8                 1.285
                                                                                           1.028
  5     87.8      40.4     47.4       56.2     3.964    0.562     5.087    43.4    3.1                 2.313
                                                                                           1.479
  6    101.0      47.0     54.0       65.0     5.500    0.594     6.889    59.5    4.7                 3.792
                                                                                           1.458
  7    116.1      53.6     62.4       74.5     6.840    0.599     8.038    77.3    6.0                 5.251
                                                                                           1.818
  8    133.5      61.7     71.8       85.6     8.329    0.563     9.456    98.1    7.5                 7.068
                                                                                           3.109
  9    159.9      73.9     86.0      102.6    10.486    0.523    11.531   129.6    9.6                10.177
                                                                                          -1.220
 10     79.8      37.0     42.8       51.3     9.730    0.240    10.209    34.0    8.9                 8.957
                                                                                           0.091
 11     79.7      37.0     42.7       51.2     9.890    0.190    10.270    34.0    9.0                 9.048
                                                                                           0.0
 12     74.0      38.2     35.8       50.1     9.890    0.190    10.270    30.2    9.0                 9.048
                                                                                          -0.002
 13     69.2      40.6     28.6       50.1     9.885    0.193    10.270    29.1    9.0                 9.046
                                                                                          -0.005
 14     64.1      42.7     21.4       49.8     9.865    0.203    10.270    28.6    9.0                 9.041
                                                                                          -0.007
 15     59.2      45.0     14.2       49.7     9.826    0.222    10.270    29.7    9.0                 9.034
                                                                                          -0.004
 16     54.2      47.2      7.0       49.5     9.791    0.240    10.270    31.6    8.9                 9.031
                                                                                          -0.003
 17     50.0      50.0      0.0       50.0     9.711    0.280    10.270    35.4    8.9                 9.028
                                                                                           0.0
 18     50.2      50.2      0.0       50.2     9.682    0.294    10.270    35.6    8.8                 9.028
                                                                                           0.0
 19     50.4      50.4      0.0       50.4     9.633    0.319    10.270    35.9    8.8                 9.028
---------------------------------------------------------------------------------------------------------------------
                                                                                           0.0
 20     49.4      49.4      0.0       49.4     9.600    0.335    10.270    34.5    8.8                 9.028
                                                                                           0.0
 21     48.7      48.7      0.0       48.7     9.552    0.359    10.270    33.6    8.7                 9.028
                                                                                           0.0
 22     48.0      48.0      0.0       48.0     9.523    0.374    10.270    32.6    8.7                 9.028
                                                                                           0.0
 23     46.6      46.6      0.0       46.6     9.498    0.386    10.270    30.8    8.6                 9.028
                                                                                           0.0
 24     46.7      46.7      0.0       46.7     9.495    0.388    10.270    30.9    8.6                 9.028
                                                                                           0.0
 25     47.9      47.9      0.0       47.9     9.474    0.398    10.270    32.5    8.6                 9.028
                                                                                           0.0
 26     47.7      47.7      0.0       47.7     9.437    0.416    10.270    32.2    8.6                 9.028
                                                                                           0.0
 27     47.8      47.8      0.0       47.8     9.398    0.436    10.270    32.3    8.5                 9.028
                                                                                           0.0
 28     49.2      49.2      0.0       49.2     9.352    0.459    10.270    34.2    8.5                 9.028
```

```
UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

ENERGY CALCULATIONS

****    NATURAL STRAIN     ****

SAMPLE NO. = T 712      (REMOULDED SAMPLE)
TEST RESULTS     START    161183     END      11283


 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     50.3      25.0     25.3      33.4     0.854    0.483     1.820     0.0     0.0                 0.0
                                                                                           0.160
  2     57.8      28.9     28.9      38.5     1.078    0.554     2.186     8.3     0.2                 0.160
                                                                                           0.400
  3     66.5      31.9     34.6      43.4     1.642    0.636     2.914    18.9     0.8                 0.560
                                                                                           0.757
  4     76.5      35.9     40.6      49.4     2.658    0.681     4.020    30.4     1.8                 1.317
                                                                                           1.068
  5     87.8      40.4     47.4      56.2     4.045    0.588     5.221    43.4     3.2                 2.385
                                                                                           1.562
  6    101.0      47.0     54.0      65.0     5.657    0.633     6.923    59.5     4.8                 3.947
                                                                                           1.563
  7    116.1      53.6     62.4      74.5     7.085    0.647     8.379    77.3     6.2                 5.510
                                                                                           1.978
  8    133.5      61.7     71.8      85.6     8.697    0.618     9.933    98.1     7.8                 7.488
                                                                                           3.450
  9    159.9      73.9     86.0     102.6    11.077    0.587    12.252   129.6    10.2                10.939
                                                                                          -1.364
 10     79.8      37.0     42.8      51.3    10.236    0.266    10.768    34.0     9.4                 9.575
                                                                                           0.101
 11     79.7      37.0     42.7      51.2    10.414    0.211    10.837    34.0     9.6                 9.676
                                                                                           0.0
 12     74.0      38.2     35.8      50.1    10.414    0.211    10.837    30.2     9.6                 9.676
                                                                                          -0.002
 13     69.2      40.6     28.6      50.1    10.408    0.214    10.837    29.1     9.6                 9.674
                                                                                          -0.006
 14     64.1      42.7     21.4      49.8    10.386    0.225    10.837    28.6     9.5                 9.668
                                                                                          -0.008
 15     59.2      45.0     14.2      49.7    10.343    0.247    10.837    29.7     9.5                 9.661
                                                                                          -0.004
 16     54.2      47.2      7.0      49.5    10.304    0.266    10.837    31.6     9.5                 9.657
                                                                                          -0.003
 17     50.0      50.0      0.0      50.0    10.215    0.311    10.837    35.4     9.4                 9.653
                                                                                          -0.000
 18     50.2      50.2      0.0      50.2    10.183    0.327    10.837    35.6     9.3                 9.653
                                                                                          -0.000
 19     50.4      50.4      0.0      50.4    10.129    0.354    10.837    35.9     9.3                 9.653
--------------------------------------------------------------------------------------------------------------------

                                                                                          -0.000
 20     49.4      49.4      0.0      49.4    10.093    0.372    10.837    34.5     9.2                 9.653
                                                                                          -0.000
 21     48.7      48.7      0.0      48.7    10.039    0.399    10.837    33.6     9.2                 9.653
                                                                                          -0.000
 22     48.0      48.0      0.0      48.0    10.007    0.415    10.837    32.6     9.2                 9.653
                                                                                          -0.000
 23     46.6      46.6      0.0      46.6     9.979    0.429    10.837    30.8     9.1                 9.653
                                                                                          -0.000
 24     46.7      46.7      0.0      46.7     9.976    0.430    10.837    30.9     9.1                 9.653
                                                                                          -0.000
 25     47.9      47.9      0.0      47.9     9.953    0.442    10.837    32.5     9.1                 9.653
                                                                                          -0.000
 26     47.7      47.7      0.0      47.7     9.913    0.462    10.837    32.2     9.1                 9.653
                                                                                          -0.000
 27     47.8      47.8      0.0      47.8     9.869    0.484    10.837    32.3     9.0                 9.653
                                                                                          -0.000
 28     49.2      49.2      0.0      49.2     9.818    0.509    10.837    34.2     9.0                 9.653
```

```
UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

SAMPLE NO. : T 712      (REMOULDED SAMPLE)

SAMPLE HEIGHT AFTER CONSOLIDATION =  11.383 CENTIMETRES
SAMPLE VOLUME AFTER CONSOLIDATION = 506.860 CUBIC CENTIMETRES
SAMPLE AREA AFTER CONSOLIDATION   =  44.526 SQUARE CENTIMETRES

CONSTANT LOAD                     =   16.49  N .
PROVING RING FACTOR               =  1.2365  N ./DIV
PISTON AREA                       =  5.0700 SQUARE CENTIMETRES

INITIAL DIAL READING              = 1807.00 DIVISIONS


SHEAR TEST RESULTS    START     21283     END      41283


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      PCSTRN   KPA      KPA      STRESS   KPA      STRESS    EFF SIFMA3
                                                                     KPA               KPA

   1    854    1807.0    111.0    200.3   0.0        82.4     79.8      1.3      2.6     80.7     1.033      0.0
   2    900    1804.1    119.2    196.4   0.03       88.4     83.5      2.5      4.9     85.1     1.059     -1.70
   3    910    1800.5    141.0    197.0   0.06       94.0     83.0      5.5     11.0     86.7     1.132     -0.40
   4    920    1796.7    162.7    198.4   0.09       98.6     81.6      8.5     17.0     87.3     1.208     -0.13
   5    930    1792.4    182.4    200.2   0.13      102.2     79.8     11.2     22.4     87.3     1.281     -0.01
   6    940    1787.9    205.0    202.6   0.17      106.1     77.4     14.4     28.7     87.0     1.371      0.09
   7    950    1783.1    224.0    204.4   0.21      109.5     75.5     17.0     34.0     86.8     1.450      0.13
   8   1000    1778.8    238.9    206.0   0.25      112.0     73.9     19.0     38.1     86.6     1.515      0.16
   9   1015    1771.3    265.8    208.6   0.31      116.8     71.3     22.8     45.5     86.5     1.638      0.19
  10   1030    1763.2    290.4    210.8   0.38      121.4     69.1     26.1     52.3     86.5     1.757      0.21
  11   1045    1754.9    312.5    213.5   0.46      124.7     66.4     29.2     58.3     85.8     1.879      0.24
  12   1115    1738.0    355.0    216.5   0.61      133.1     63.1     35.0     70.0     86.4     2.110      0.24
  13   1130    1729.4    374.0    217.7   0.68      137.2     62.0     37.6     75.2     87.1     2.213      0.24
  14   1145    1714.5    393.5    219.4   0.81      140.8     60.3     40.2     80.5     87.1     2.335      0.25
  15   1200    1710.0    407.5    210.7   0.85      153.6     69.3     42.1     84.3     97.4     2.216      0.13
  16   1216    1698.3    422.1    209.7   0.95      158.4     70.2     44.1     88.2     99.6     2.256      0.11
  17   1240    1681.7    441.8    209.3   1.10      164.1     70.6     46.7     93.5    101.8     2.324      0.10
  18   1300    1665.7    457.0    209.3   1.24      167.9     70.4     48.8     97.5    102.9     2.385      0.09
  19   1320    1650.0    468.7    209.2   1.38      171.2     70.6     50.3    100.6    104.1     2.425      0.09
  20   1333    1640.1    473.8    208.7   1.47      172.9     71.0     51.0    101.9    105.0     2.435      0.08
  21   1402    1616.2    483.5    208.0   1.68      176.0     71.6     52.2    104.4    106.4     2.457      0.08
  22   1430    1591.1    490.9    208.2   1.90      177.5     71.4     53.1    106.1    106.8     2.487      0.08
  23   1512    1552.5    498.0    208.3   2.24      179.2     71.5     53.8    107.7    107.4     2.506      0.08
  24   1530    1536.9    500.6    208.3   2.37      179.6     71.4     54.1    108.2    107.5     2.516      0.08
  25   1600    1509.0    504.0    208.2   2.62      180.5     71.6     54.4    108.9    107.9     2.521      0.07
  26   1630    1481.4    508.2    208.2   2.86      181.3     71.5     54.9    109.8    108.1     2.535      0.07
-------------------------------------------------------------------------------------------------------------------------

  27   1655    1458.1    511.2    208.4   3.06      181.5     71.2     55.2    110.3    108.0     2.550      0.08
  28   1659    1454.7    511.2    208.4   3.09      181.4     71.1     55.2    110.3    107.9     2.552      0.08
  29   1700    1454.7    511.2    RELAXATION TEST
  30   1701    1453.5    509.0    RELAXATION TEST
  31   1702    1453.0    507.2    RELAXATION TEST
  32   1704    1452.2    504.6    RELAXATION TEST
  33   1708    1450.9    499.3    RELAXATION TEST
  34   1715    1449.1    492.2    RELAXATION TEST
  35   1730    1446.5    482.7    RELAXATION TEST
  36   2029    1436.0    443.2    RELAXATION TEST
  37    900    1424.0    396.0    RELAXATION TEST
  38    930    1424.0    395.0    182.1   3.36      176.7     97.9     39.4     78.8    124.2     1.805     -0.24
  39    940    1420.8    415.2    178.2   3.39      186.0    101.8     42.1     84.2    129.9     1.827     -0.27
  40    950    1417.0    438.1    178.6   3.43      191.6    101.3     45.1     90.3    131.4     1.891     -0.25
  41   1000    1412.8    458.1    179.2   3.46      196.3    100.7     47.8     95.6    132.6     1.950     -0.23
  42   1015    1406.0    483.9    180.7   3.52      201.7     99.2     51.2    102.5    133.4     2.033     -0.20
  43   1030    1397.5    506.3    182.4   3.60      205.9     97.5     54.2    108.4    133.6     2.112     -0.17
  44   1045    1387.4    523.8    184.0   3.69      208.8     95.8     56.5    113.0    133.5     2.179     -0.15
  45   1100    1376.5    537.0    185.3   3.78      211.0     94.6     58.2    116.4    133.4     2.230     -0.13
  46   1115    1365.2    545.8    186.4   3.88      211.9     93.3     59.3    118.6    132.8     2.272     -0.12
  47   1130    1353.2    552.2    187.3   3.99      212.6     92.4     60.1    120.2    132.5     2.301     -0.11
  48   1145    1339.2    557.0    188.2   4.11      212.8     91.5     60.7    121.3    131.9     2.326     -0.10
  49   1200    1327.0    560.1    188.9   4.22      212.7     90.7     61.0    122.0    131.4     2.345     -0.10
  50   1230    1300.3    564.2    190.0   4.45      212.5     89.7     61.4    122.8    130.6     2.369     -0.09
  51   1300    1271.7    568.0    191.4   4.70      212.0     88.5     61.7    123.5    129.7     2.395     -0.07
  52   1400    1215.8    574.2    193.3   5.19      211.2     86.7     62.2    124.5    128.2     2.436     -0.06
  53   1500    1162.4    578.0    195.0   5.66      209.8     85.0     62.4    124.8    126.6     2.469     -0.04
  54   1601    1106.5    582.8    196.1   6.15      209.2     83.7     62.7    125.5    125.5     2.499     -0.03
  55   1700    1051.8    587.4    196.7   6.63      209.0     83.0     63.0    126.0    125.0     2.518     -0.03
  56   1809     993.1    595.1    197.1   7.15      210.1     82.8     63.6    127.3    125.2     2.537     -0.03
  57   1904     941.6    599.5    197.8   7.60      209.7     81.9     63.9    127.8    124.5     2.561     -0.02
  58    918     154.2    663.4    197.0  14.52      216.8     83.5     66.7    133.3    127.9     2.597     -0.03
  59    955     121.5    667.9    193.5  14.81      220.7     86.7     67.0    134.0    131.4     2.545     -0.05
  60   1019      99.0    670.3    192.7  15.00      221.6     87.3     67.1    134.3    132.1     2.538     -0.06
```

```
UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

SAMPLE NO. = T 712      (REMOULDED SAMPLE)

CONSOLIDATION AXIAL STRESS          =   80.00 KPA
PRECONSOLIDATION PRESSURE           =  159.89 KPA
NORMALIZING STRESS                  =  159.89 KPA

NORMALIZED SHEAR TEST RESULTS     START      21283      END      41283

 PT      PER        NRMLZD      EFFECT    NRMLZD     NRMLZD
         CENT       HALF        RATIO     OCT        CHANGE
         PCSTRN     DEV         SIGMA1    STRESS     IN PWP
                    STRESS      SIGMA3    KPA        KPA
                    KPA

  1      0.0        0.008       1.033     0.505      0.0
  2      0.03       0.015       1.059     0.533     -0.024
  3      0.06       0.034       1.132     0.542     -0.021
  4      0.09       0.053       1.208     0.546     -0.012
  5      0.13       0.070       1.281     0.546     -0.001
  6      0.17       0.090       1.371     0.544      0.014
  7      0.21       0.106       1.450     0.543      0.026
  8      0.25       0.119       1.515     0.542      0.036
  9      0.31       0.142       1.638     0.541      0.052
 10      0.38       0.163       1.757     0.541      0.066
 11      0.46       0.182       1.879     0.537      0.083
 12      0.61       0.219       2.110     0.541      0.101
 13      0.68       0.235       2.213     0.545      0.109
 14      0.81       0.252       2.335     0.545      0.119
 15      0.85       0.263       2.216     0.609      0.065
 16      0.95       0.276       2.256     0.623      0.059
 17      1.10       0.292       2.324     0.636      0.056
 18      1.24       0.305       2.385     0.644      0.056
 19      1.38       0.315       2.425     0.651      0.056
 20      1.47       0.319       2.435     0.657      0.053
 21      1.68       0.326       2.457     0.665      0.048
 22      1.90       0.332       2.487     0.668      0.049
 23      2.24       0.337       2.506     0.672      0.050
 24      2.37       0.338       2.516     0.672      0.050
 25      2.62       0.340       2.521     0.675      0.049
 26      2.86       0.343       2.535     0.676      0.049
 27      3.06       0.345       2.550     0.675      0.051
 28      3.09       0.345       2.552     0.675      0.051
 38      3.36       0.246       1.805     0.777     -0.114
 39      3.39       0.263       1.827     0.812     -0.138
 40      3.43       0.282       1.891     0.822     -0.136
 41      3.46       0.299       1.950     0.829     -0.132
 42      3.52       0.320       2.033     0.834     -0.123
 43      3.60       0.339       2.112     0.836     -0.112
 44      3.69       0.353       2.179     0.835     -0.102
 45      3.78       0.364       2.230     0.834     -0.094

 46      3.88       0.371       2.272     0.831     -0.087
 47      3.99       0.376       2.301     0.829     -0.081
 48      4.11       0.379       2.326     0.825     -0.076
 49      4.22       0.382       2.345     0.822     -0.071
 50      4.45       0.384       2.369     0.817     -0.064
 51      4.70       0.386       2.395     0.811     -0.056
 52      5.19       0.389       2.436     0.802     -0.044
 53      5.66       0.390       2.469     0.792     -0.033
 54      6.15       0.392       2.499     0.785     -0.026
 55      6.63       0.394       2.518     0.782     -0.023
 56      7.15       0.398       2.537     0.783     -0.020
 57      7.60       0.400       2.561     0.779     -0.016
 58     14.52       0.417       2.597     0.800     -0.021
 59     14.81       0.419       2.545     0.822     -0.043
 60     15.00       0.420       2.538     0.826     -0.048
```

```
UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

SAMPLE NO. : T 714      (REMOULDED SAMPLE)
INITIAL MOISTURE CONTENT             :   46.5 PERCENT
SPECIFIC GRAVITY OF SOIL             :  2.73
INITIAL VOID RATIO                   :   1.271
INITIAL HEIGHT OF SAMPLE             :  12.99 CM
INITIAL VOLUME OF SAMPLE             :  592.26 CC
EFFECTIVE PRINCIPAL STRESS RATIO     :  1.00
FINAL MOISTURE CONTENT               :   38.5 PERCENT

TX.  CONSOLIDATION    START    131283     END     30184
TRIAXIAL CONSOLIDATION TEST
:::::::::::::::::::::::::::



 PT  EFFECT    EFFECT   STRAIN1    VOLUME  STRAIN3    EFFECT       Q        VOID        V       SHEAR
     SIGMA1    SIGMA3              STRAIN                P                  RATIO               STRAIN

  1   50.04     26.50     1.133     1.545    0.206     34.35     23.54     1.235     2.235     0.618
  2   57.62     30.50     1.317     1.832    0.258     39.54     27.12     1.229     2.229     0.706
  3   66.33     35.10     1.624     2.381    0.378     45.51     31.23     1.216     2.216     0.830
  4   76.30     40.40     2.134     3.149    0.508     52.37     35.90     1.199     2.199     1.084
  5   87.88     46.50     2.762     4.086    0.662     60.29     41.38     1.178     2.178     1.400
  6  101.11     53.50     3.886     5.386    0.750     69.37     47.61     1.148     2.148     2.091
  7  116.28     61.60     5.052     6.686    0.817     79.83     54.68     1.119     2.119     2.823
  8  133.91     70.90     6.322     8.206    0.942     91.90     63.01     1.084     2.084     3.587
  9  160.00     84.80     8.004     9.911    0.954    109.87     75.20     1.046     2.046     4.700
 10   79.73     42.40     7.231     8.518    0.644     54.84     37.33     1.077     2.077     4.392
 11   79.68     42.40     7.329     8.476    0.574     54.83     37.28     1.078     2.078     4.504
 12   76.30     44.90     7.329     8.476    0.574     55.37     31.40     1.078     2.078     4.504
 13   73.10     48.00     7.324     8.476    0.576     56.37     25.10     1.078     2.078     4.499
 14   69.20     50.40     7.301     8.476    0.587     56.67     18.80     1.078     2.078     4.476
 15   65.10     52.60     7.269     8.476    0.604     56.77     12.50     1.078     2.078     4.443
 16   61.20     55.00     7.221     8.476    0.627     57.07      6.20     1.078     2.078     4.396
 17   57.20     57.20     7.146     8.476    0.665     57.20      0.0      1.078     2.078     4.320
 18   53.80     53.80     7.106     8.476    0.685     53.80      0.0      1.078     2.078     4.280
 19   54.50     54.50     7.065     8.476    0.706     54.50      0.0      1.078     2.078     4.239
 20   56.30     56.30     7.036     8.476    0.720     56.30      0.0      1.078     2.078     4.211
 21   56.90     56.90     7.007     8.476    0.735     56.90      0.0      1.078     2.078     4.182
 22   56.60     56.60     6.976     8.476    0.750     56.60      0.0      1.078     2.078     4.151
 23   54.60     54.60     6.953     8.476    0.761     54.60      0.0      1.078     2.078     4.128
 24   55.00     55.00     6.959     8.476    0.758     55.00      0.0      1.078     2.078     4.134
 25   55.10     55.10     6.931     8.476    0.773     55.10      0.0      1.078     2.078     4.105
 26   55.10     55.10     6.902     8.476    0.787     55.10      0.0      1.078     2.078     4.077
 27   54.80     54.80     6.888     8.476    0.804     54.80      0.0      1.078     2.078     4.042
 28   53.80     53.80     6.718     8.476    0.879     53.80      0.0      1.078     2.078     3.893
 29   47.50     47.50     6.616     8.476    0.930     47.50      0.0      1.078     2.078     3.790
--------------------------------------------------------------------------------------------------------------------------

 30   42.70     42.70     6.508     8.476    0.984     42.70      0.0      1.078     2.078     3.683
 31   40.80     40.80     6.427     8.476    1.024     40.80      0.0      1.078     2.078     3.602
 32   38.80     38.80     6.359     8.476    1.059     38.80      0.0      1.078     2.078     3.533
 33   37.40     37.40     6.306     8.476    1.085     37.40      0.0      1.078     2.078     3.481
 34   34.90     34.90     6.235     8.476    1.120     34.90      0.0      1.078     2.078     3.410
```

```
SUMMARY OF ESSENTIAL RESULTS STORED IN FILE


  PT  SIGMA1    SIGMA3    STRAIN1   STRAIN3     V

   1   50.04     26.50     1.133     0.206     2.235
   2   57.62     30.50     1.317     0.258     2.228
   3   66.33     35.10     1.624     0.378     2.216
   4   76.30     40.40     2.134     0.508     2.199
   5   87.86     46.50     2.762     0.662     2.178
   6  101.11     53.50     3.886     0.750     2.148
   7  116.28     61.60     5.052     0.817     2.119
   8  133.91     70.90     6.322     0.942     2.084
   9  160.00     84.80     8.004     0.954     2.046
  10   79.73     42.40     7.231     0.644     2.077
  11   79.68     42.40     7.329     0.574     2.078
  12   76.30     44.90     7.329     0.574     2.078
  13   73.10     48.00     7.324     0.576     2.078
  14   69.20     50.40     7.301     0.587     2.078
  15   65.10     52.60     7.268     0.604     2.078
  16   61.20     55.00     7.221     0.627     2.078
  17   57.20     57.20     7.146     0.665     2.078
  18   53.80     53.80     7.106     0.685     2.078
  19   54.50     54.50     7.066     0.705     2.078
  20   55.30     55.30     7.036     0.720     2.078
  21   55.90     55.90     7.007     0.735     2.078
  22   55.8C     55.80     6.976     0.750     2.078
  23   54.60     54.60     6.953     0.761     2.078
  24   55.00     55.00     6.959     0.758     2.078
  25   55.10     55.10     6.931     0.773     2.078
  26   55.10     55.10     6.902     0.787     2.078
  27   54.80     54.80     6.868     0.804     2.078
  28   53.60     53.60     6.718     0.878     2.078
  29   47.50     47.50     6.616     0.930     2.078
  30   42.70     42.70     6.508     0.984     2.078
  31   40.80     40.80     6.427     1.024     2.078
  32   38.80     38.80     6.358     1.059     2.078
  33   37.40     37.40     6.306     1.085     2.078
  34   34.80     34.80     6.235     1.120     2.078
```

```
UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

ENERGY CALCULATIONS

****  ENGINEERING STRAIN  ****

SAMPLE NO. = T 714      (REMOULDED SAMPLE)
TEST RESULTS     START    131283      END       30184


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    50.0     26.5     23.5    34.3    1.133   0.206    1.545     0.0    0.0              0.0
                                                                                 0.128
 2    57.6     30.5     27.1    39.5    1.317   0.258    1.832     9.5    0.2              0.128
                                                                                 0.270
 3    66.3     35.1     31.2    45.5    1.624   0.378    2.381    20.3    0.5              0.398
                                                                                 0.461
 4    76.3     40.4     35.9    52.4    2.134   0.508    3.149    32.6    1.1              0.859
                                                                                 0.650
 5    87.9     46.5     41.4    60.3    2.762   0.662    4.086    47.2    1.6              1.509
                                                                                 1.150
 6   101.1     53.5     47.6    69.4    3.886   0.750    5.386    63.8    2.9              2.659
                                                                                 1.344
 7   116.3     61.6     54.7    79.8    5.052   0.817    6.686    82.6    4.0              4.004
                                                                                 1.754
 8   133.9     70.9     63.0    91.9    6.322   0.942    8.206   104.6    5.3              5.758
                                                                                 2.490
 9   160.0     84.8     75.2   109.9    8.004   0.954    9.911   137.4    7.0              8.248
                                                                                -1.321
10    79.7     42.4     37.3    54.8    7.231   0.644    8.518    37.2    6.1              6.927
                                                                                 0.019
11    79.7     42.4     37.3    54.8    7.329   0.574    8.476    37.2    6.2              6.946
                                                                                 0.0
12    76.3     44.9     31.4    55.4    7.329   0.574    8.476    37.0    6.2              6.946
                                                                                -0.001
13    73.1     48.0     25.1    56.4    7.324   0.576    8.476    38.2    6.2              6.944
                                                                                -0.005
14    69.2     50.4     18.8    56.7    7.301   0.587    8.476    36.9    6.2              6.939
                                                                                -0.005
15    65.1     52.6     12.5    56.8    7.268   0.604    8.476    39.9    6.2              6.934
                                                                                -0.004
16    61.2     55.0      6.2    57.1    7.221   0.627    8.476    41.6    6.1              6.930
                                                                                -0.002
17    57.2     57.2      0.0    57.2    7.146   0.665    8.476    44.0    6.0              6.927
                                                                                 0.0
18    53.8     53.8      0.0    53.8    7.106   0.685    8.476    38.5    6.0              6.927
                                                                                 0.0
19    54.5     54.5      0.0    54.5    7.066   0.705    8.476    39.5    6.0              6.927
```

```
                                                                                     0.0
 20     56.3     56.3     0.0     56.3     7.036   0.720    8.476    42.6    5.9              6.927
                                                                                     0.0
 21     56.9     56.9     0.0     56.9     7.007   0.735    8.476    43.5    5.9              6.927
                                                                                     0.0
 22     56.6     56.6     0.0     56.6     6.976   0.750    8.476    43.1    5.9              6.927
                                                                                     0.0
 23     54.6     54.6     0.0     54.6     6.953   0.761    8.476    40.0    5.9              6.927
                                                                                     0.0
 24     55.0     55.0     0.0     55.0     6.959   0.758    8.476    40.6    5.8              6.927
                                                                                     0.0
 25     55.1     55.1     0.0     55.1     6.931   0.773    8.476    40.8    5.9              6.927
                                                                                     0.0
 26     55.1     55.1     0.0     55.1     6.902   0.787    8.476    40.6    5.8              6.927
                                                                                     0.0
 27     54.8     54.8     0.0     54.8     6.868   0.804    8.476    40.3    5.6              6.927
                                                                                     0.0
 28     53.6     53.6     0.0     53.6     6.718   0.879    8.476    38.8    5.7              6.927
                                                                                     0.0
 29     47.5     47.5     0.0     47.5     6.616   0.930    8.476    28.8    5.6              6.927
                                                                                     0.0
 30     42.7     42.7     0.0     42.7     6.508   0.984    8.476    24.1    5.5              6.927
                                                                                    -0.000
 31     40.8     40.8     0.0     40.8     6.427   1.024    8.476    22.2    5.4              6.927
                                                                                     0.000
 32     38.8     38.8     0.0     38.8     6.359   1.059    8.476    20.7    5.4              6.927
                                                                                     0.0
 33     37.4     37.4     0.0     37.4     6.306   1.085    8.476    19.9    5.3              6.927
                                                                                    -0.000
 34     34.9     34.9     0.0     34.9     6.235   1.120    8.476    18.2    5.3              6.927
```

```
UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

ENERGY CALCULATIONS

****     NATURAL STRAIN     ****

SAMPLE NO. = T 714      (REMOULDED SAMPLE)
TEST RESULTS      START     131283      END      30184

 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     50.0      26.5     23.5      34.3     1.140    0.209    1.557     0.0     0.0                 0.0
                                                                                          0.130
  2     57.6      30.5     27.1      39.5     1.325    0.262    1.849     9.5     0.2                 0.130
                                                                                          0.275
  3     66.3      35.1     31.2      45.5     1.637    0.386    2.409    20.3     0.6                 0.405
                                                                                          0.473
  4     76.3      40.4     35.9      52.4     2.157    0.521    3.200    32.8     1.1                 0.878
                                                                                          0.671
  5     87.9      46.5     41.4      60.3     2.801    0.686    4.172    47.2     1.8                 1.549
                                                                                          1.200
  6    101.1      53.5     47.6      69.4     3.964    0.786    5.537    63.8     2.9                 2.749
                                                                                          1.420
  7    116.3      61.6     54.7      79.8     5.184    0.868    6.920    82.8     4.2                 4.169
                                                                                          1.880
  8    133.9      70.9     63.0      91.9     6.531    1.016    8.562   104.6     5.5                 6.050
                                                                                          2.712
  9    160.0      84.8     75.2     109.9     8.343    1.047   10.437   137.4     7.3                 8.761
                                                                                         -1.447
 10     79.7      42.4     37.3      54.8     7.506    0.699    8.903    37.2     6.4                 7.315
                                                                                          0.020
 11     79.7      42.4     37.3      54.8     7.611    0.623    8.857    37.2     6.5                 7.334
                                                                                          0.0
 12     76.3      44.9     31.4      55.4     7.611    0.623    8.857    37.0     6.5                 7.334
                                                                                         -0.001
 13     73.1      48.0     25.1      56.4     7.608    0.625    8.857    38.2     6.5                 7.333
                                                                                         -0.006
 14     69.2      50.4     18.8      56.7     7.581    0.638    8.857    38.9     6.5                 7.327
                                                                                         -0.005
 15     65.1      52.6     12.5      56.8     7.546    0.655    8.857    39.9     6.4                 7.322
                                                                                         -0.005
 16     61.2      55.0      6.2      57.1     7.485    0.686    8.857    41.6     6.4                 7.317
                                                                                         -0.003
 17     57.2      57.2      0.0      57.2     7.414    0.722    8.857    44.0     6.3                 7.315
                                                                                         -0.000
 18     53.8      53.8      0.0      53.8     7.371    0.743    8.857    38.8     6.3                 7.315
                                                                                         -0.000
 19     54.5      54.5      0.0      54.5     7.327    0.765    8.857    39.6     6.2                 7.315
```

20	56.3	56.3	0.0	56.3	7.286	0.780	8.857	42.6	6.2	-0.000	7.315
21	55.9	55.9	0.0	55.9	7.264	0.786	8.857	43.5	6.2	-0.000	7.315
22	56.6	56.6	0.0	56.6	7.231	0.813	8.857	43.1	6.2	-0.000	7.315
23	54.6	54.6	0.0	54.6	7.207	0.825	8.857	40.0	6.1	-0.000	7.315
24	55.0	55.0	0.0	55.0	7.213	0.822	8.857	40.6	6.1	-0.000	7.315
25	55.1	55.1	0.0	55.1	7.183	0.837	8.857	40.8	6.1	-0.000	7.315
26	55.1	55.1	0.0	55.1	7.152	0.852	8.857	40.6	6.1	-0.000	7.315
27	54.8	54.8	0.0	54.8	7.115	0.871	8.857	40.3	6.0	-0.000	7.315
28	53.8	53.8	0.0	53.8	6.954	0.881	8.857	38.8	5 9	-0.000	7.315
29	47.5	47.5	0.0	47.5	6.845	1.006	8.857	29.8	5.8	-0.000	7.315
30	42.7	42.7	0.0	42.7	6.729	1.064	8.857	24.1	5.7	-0.000	7.315
31	40.8	40.8	0.0	40.8	6.643	1.107	8.857	22.2	5.6	-0.000	7.315
32	38.8	38.8	0.0	38.8	6.570	1.144	8.857	20.7	5.6	-0.000	7.315
33	37.4	37.4	0.0	37.4	6.514	1.171	8.857	19.9	5.5	-0.000	7.315
34	34.9	34.9	0.0	34.9	6.438	1.209	8.857	18.2	5.5	-0.000	7.315

```
UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

SAMPLE NO. = T 714      (REMOULDED SAMPLE)

SAMPLE HEIGHT AFTER CONSOLIDATION =  12.136 CENTIMETRES
SAMPLE VOLUME AFTER CONSOLIDATION = 534.256 CUBIC CENTIMETRES
SAMPLE AREA AFTER CONSOLIDATION   =  44.022 SQUARE CENTIMETRES

CONSTANT LOAD                     =   11.42  N .
PROVING RING FACTOR               =  1.0225  N ./DIV
PISTON AREA                       =  2.8500 SQUARE CENTIMETRES

INITIAL DIAL READING              = 1249.20 DIVISIONS


SHEAR TEST RESULTS     START      40184       END      60184


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      PCSTRN   KPA      KPA      STRESS   KPA      STRESS   EFF SIFMA3
                                                                      KPA               KPA

  1   810      1249.2     74.8    200.0    0.0       81.8     80.0      0.9      1.8     80.6     1.023       0.0
  2   820      1241.6     75.8    201.1    0.06      81.3     79.2      1.0      2.1     79.9     1.026       5.20
  3   830      1232.4     75.8    201.3    0.14      81.1     79.0      1.0      2.1     79.7     1.026       6.19
  4   845      1225.2    103.2    203.9    0.20      84.6     76.2      4.2      8.4     79.0     1.110       0.59
  5   900      1220.2    138.0    207.9    0.24      89.0     72.5      8.2     16.5     78.0     1.227       0.54
  6   917      1213.0    175.5    212.1    0.30      93.3     68.2     12.6     25.1     76.6     1.369       0.52
  7   930      1205.0    195.5    214.6    0.36      95.4     65.6     14.9     29.8     75.5     1.454       0.52
  8   947      1198.0    225.5    218.0    0.42      99.0     62.3     18.3     36.7     74.5     1.589       0.52
  9  1000      1189.7    246.2    220.0    0.49     101.7     60.3     20.7     41.4     74.1     1.687       0.51
 10  1015      1182.5    266.5    221.9    0.55     104.3     58.2     23.1     46.1     73.6     1.792       0.49
 11  1030      1173.5    286.5    224.0    0.62     107.2     56.5     25.3     50.7     73.4     1.897       0.49
 12  1045      1164.9    305.0    225.5    0.69     109.7     54.8     27.5     54.9     73.1     2.002       0.48
 13  1100      1154.5    322.4    227.0    0.78     112.3     53.4     29.4     58.9     73.0     2.102       0.47
 14  1115      1144.6    339.0    228.4    0.86     114.6     52.0     31.3     62.6     72.9     2.205       0.47
 15  1130      1134.3    353.5    229.3    0.95     116.8     50.9     33.0     65.9     72.9     2.295       0.46
 16  1145      1127.0    370.5    230.5    1.01     119.6     49.8     34.9     69.8     73.1     2.402       0.45
 17  1200      1116.4    380.0    231.3    1.09     120.8     48.9     36.0     71.9     72.9     2.471       0.45
 18  1215      1105.2    392.5    231.8    1.19     123.0     48.3     37.4     74.7     73.2     2.547       0.44
 19  1230      1091.2    402.2    232.4    1.30     124.7     47.8     38.4     76.9     73.4     2.608       0.43
 20  1245      1083.0    410.4    233.1    1.37     125.9     47.2     39.3     78.7     73.4     2.667       0.43
 21  1301      1071.9    418.4    233.3    1.46     127.4     47.0     40.2     80.4     73.8     2.712       0.42
 22  1314      1056.8    421.0    233.3    1.59     127.8     46.9     40.5     80.9     73.9     2.726       0.42
 23  1332      1041.5    428.8    233.7    1.71     129.0     46.4     41.3     82.6     73.9     2.781       0.42
 24  1345      1030.0    432.0    233.9    1.81     129.6     46.3     41.6     83.3     74.1     2.798       0.42
 25  1400      1010.4    434.0    233.8    1.97     129.9     46.3     41.8     83.6     74.2     2.805       0.41
 26  1419       993.5    440.0    234.2    2.11     130.6     45.8     42.4     84.8     74.1     2.852       0.41

---------------------------------------------------------------------------------------------------------------------

 27  1442       972.3    442.1    234.1    2.28     130.9     45.7     42.6     85.2     74.1     2.864       0.41
 28  1525       932.9    448.5    234.7    2.61     131.4     45.1     43.2     86.3     73.9     2.915       0.41
 29  1603       900.2    455.9    235.0    2.88     132.7     44.9     43.9     87.8     74.2     2.955       0.41
 30  1610       893.2    454.9    234.9    2.93     132.5     45.0     43.7     87.5     74.2     2.944       0.41
 31  1611       893.1    453.2    RELAXATION TEST
 32  1612       892.8    452.0    RELAXATION TEST
 33  1614       892.2    448.5    RELAXATION TEST
 34  1618       890.8    443.4    RELAXATION TEST
 35  1625       890.0    439.2    RELAXATION TEST
 36  1635       888.9    434.5    RELAXATION TEST
 37  1650       887.9    429.8    RELAXATION TEST
 38  1720       886.1    424.3    RELAXATION TEST
 39   830       875.8    390.0    RELAXATION TEST
 40   836       875.8    390.9    235.4    3.08     117.9     45.0     36.5     72.9     69.3     2.621       0.50
 41   845       873.5    412.0    237.0    3.10     121.2     43.5     38.8     77.7     69.4     2.785       0.49
 42   900       867.8    441.3    238.6    3.14     126.3     42.1     42.1     84.2     70.2     3.000       0.47
 43   915       858.2    455.5    239.1    3.22     129.1     41.8     43.7     87.3     70.9     3.089       0.46
 44   934       840.8    463.2    238.0    3.37     131.1     42.2     44.5     88.9     71.8     3.108       0.44
 45   945       830.0    461.0    238.0    3.45     130.6     42.2     44.2     88.4     71.7     3.094       0.44
 46  1000       814.0    459.4    237.5    3.59     130.4     42.5     44.0     87.9     71.8     3.068       0.44
 47  1020       793.3    462.6    237.7    3.76     131.0     42.6     44.2     88.4     72.1     3.076       0.44
 48  1040       776.4    463.0    237.4    3.90     130.9     42.5     44.2     88.4     72.0     3.081       0.43
 49  1100       759.5    463.0    237.5    4.04     130.8     42.5     44.2     88.3     71.9     3.078       0.43
 50  1120       740.5    460.5    237.9    4.19     130.1     42.5     43.8     87.6     71.7     3.061       0.44
 51  1201       702.2    459.4    238.2    4.51     129.4     42.4     43.5     87.0     71.4     3.053       0.45
 52  1230       674.4    458.3    238.1    4.74     128.9     42.3     43.3     86.6     71.2     3.047       0.45
 53  1303       641.8    457.8    238.5    5.00     128.3     42.1     43.1     86.2     70.8     3.048       0.46
 54  1330       618.4    457.6    238.7    5.20     127.6     41.6     43.0     86.0     70.3     3.068       0.46
 55  1400       582.6    459.2    239.3    5.41     127.7     41.5     43.1     86.2     70.2     3.076       0.47
 56  1500       529.0    460.3    239.7    5.93     127.1     41.2     43.0     85.9     69.8     3.085       0.47
 57  1727       389.7    458.4    240.8    7.08     124.7     40.3     42.2     84.4     68.4     3.095       0.49
 58   830      -460.8    460.0    242.7   14.09     116.1     37.7     39.2     78.4     63.8     3.080       0.56
 59   908      -497.3    456.5    242.5   14.39     115.3     37.8     38.7     77.5     63.6     3.049       0.56
 60   925      -512.0    455.0    242.7   14.51     114.7     37.7     38.5     77.0     63.4     3.044       0.57
```

```
UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

SAMPLE NO. : T 714     (REMOULDED SAMPLE)

CONSOLIDATION AXIAL STRESS        :   80.00 KPA
PRECONSOLIDATION PRESSURE         :  160.00 KPA
NORMALIZING STRESS                :  160.00 KPA

NORMALIZED SHEAR TEST RESULTS    START     40184     END      60184

 PT     PER       NRMLZD     EFFECT    NRMLZD     NRMLZD
        CENT      HALF       RATIO     OCT        CHANGE
        PCSTRN    DEV        SIGMA1    STRESS     IN PWP
                  STRESS     SIGMA3    KPA        KPA
                  KPA

  1     0.0       0.006      1.023     0.504      0.0
  2     0.06      0.006      1.026     0.499      0.007
  3     0.14      0.006      1.026     0.498      0.008
  4     0.20      0.026      1.110     0.494      0.024
  5     0.24      0.051      1.227     0.487      0.049
  6     0.30      0.079      1.369     0.479      0.076
  7     0.36      0.093      1.454     0.472      0.091
  8     0.42      0.115      1.589     0.466      0.112
  9     0.49      0.129      1.687     0.463      0.125
 10     0.55      0.144      1.792     0.460      0.137
 11     0.62      0.158      1.897     0.459      0.150
 12     0.69      0.172      2.002     0.457      0.159
 13     0.78      0.184      2.102     0.456      0.169
 14     0.86      0.196      2.205     0.455      0.177
 15     0.95      0.206      2.295     0.455      0.183
 16     1.01      0.218      2.402     0.457      0.191
 17     1.09      0.225      2.471     0.455      0.196
 18     1.19      0.234      2.547     0.458      0.199
 19     1.30      0.240      2.608     0.459      0.202
 20     1.37      0.246      2.667     0.459      0.207
 21     1.46      0.251      2.712     0.461      0.208
 22     1.59      0.253      2.726     0.462      0.208
 23     1.71      0.258      2.781     0.462      0.211
 24     1.81      0.260      2.798     0.463      0.212
 25     1.97      0.261      2.805     0.464      0.211
 26     2.11      0.265      2.852     0.463      0.214
 27     2.28      0.266      2.864     0.463      0.213
 28     2.61      0.270      2.915     0.462      0.217
 29     2.88      0.274      2.955     0.463      0.219
 30     2.93      0.273      2.944     0.464      0.218
 40     3.08      0.228      2.621     0.433      0.221
 41     3.10      0.243      2.785     0.434      0.231
 42     3.14      0.263      3.000     0.439      0.241
 43     3.22      0.273      3.089     0.443      0.244
 44     3.37      0.278      3.108     0.449      0.237
 45     3.45      0.276      3.094     0.448      0.237
-------------------------------------------------------------------------------------------------------------------------

 46     3.59      0.275      3.068     0.449      0.234
 47     3.76      0.276      3.076     0.451      0.236
 48     3.90      0.276      3.081     0.450      0.234
 49     4.04      0.276      3.078     0.450      0.234
 50     4.19      0.274      3.061     0.448      0.237
 51     4.51      0.272      3.053     0.446      0.239
 52     4.74      0.271      3.047     0.445      0.238
 53     5.00      0.269      3.048     0.443      0.241
 54     5.20      0.269      3.068     0.439      0.242
 55     5.41      0.269      3.076     0.439      0.246
 56     5.93      0.268      3.085     0.436      0.248
 57     7.08      0.264      3.095     0.428      0.255
 58    14.09      0.245      3.080     0.399      0.267
 59    14.39      0.242      3.049     0.398      0.266
 60    14.51      0.241      3.044     0.396      0.267
```

```
UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

SAMPLE NO. : T 716      (REMOULDED SAMPLE)
INITIAL MOISTURE CONTENT             :   50.0 PERCENT
SPECIFIC GRAVITY OF SOIL             :  2.73
INITIAL VOID RATIO                   :   1.365
INITIAL HEIGHT OF SAMPLE             :  13.05 CM
INITIAL VOLUME OF SAMPLE             :  594.03 CC
EFFECTIVE PRINCIPAL STRESS RATIO     :  1.00
FINAL MOISTURE CONTENT               :   41.3 PERCENT

TX. CONSOLIDATION    START    311283      END    140184
TRIAXIAL CONSOLIDATION TEST
::::::::::::::::::::::::::::



 PT   EFFECT    EFFECT   STRAIN1    VOLUME   STRAIN3    EFFECT       Q        VOID        V       SHEAR
      SIGMA1    SIGMA3              STRAIN                P                   RATIO               STRAIN

  1    50.06     26.50     1.808     2.104     0.148     34.35     23.56     1.315     2.315     1.107
  2    57.67     30.50     2.207     2.710     0.252     39.56     27.17     1.301     2.301     1.303
  3    66.41     35.10     2.835     3.493     0.329     45.54     31.31     1.282     2.282     1.671
  4    76.39     40.40     3.556     4.562     0.503     52.40     35.99     1.257     2.257     2.036
  5    87.80     46.50     4.780     5.909     0.564     60.27     41.30     1.225     2.225     2.810
  6   101.03     53.50     5.967     7.138     0.585     69.34     47.53     1.196     2.196     3.588
  7   116.27     61.50     7.278     8.686     0.704     79.76     54.77     1.159     2.159     4.383
  8   133.57     70.80     8.490     9.932     0.721     91.72     62.77     1.130     2.130     5.180
  9   159.90     84.80    10.360    11.683     0.661    109.83     75.10     1.089     2.089     6.466
 10    79.73     42.40     9.419    10.058     0.320     54.84     37.33     1.127     2.127     6.066
 11    79.68     42.40     9.503    10.016     0.256     54.83     37.28     1.128     2.128     6.165
 12    75.60     44.20     9.503    10.016     0.256     54.67     31.40     1.128     2.128     6.165
 13    71.90     46.80     9.500    10.016     0.258     55.17     25.10     1.128     2.128     6.161
 14    68.00     49.20     9.473    10.016     0.272     55.47     18.80     1.128     2.128     6.134
 15    64.30     51.80     9.427    10.016     0.295     55.97     12.50     1.128     2.128     6.088
 16    60.50     54.30     9.322    10.016     0.347     56.37      6.20     1.128     2.128     5.983
 17    56.40     56.40     9.221    10.016     0.397     56.40      0.0      1.128     2.128     5.883
 18    55.50     55.50     9.156    10.016     0.430     55.50      0.0      1.128     2.128     5.818
 19    54.50     54.50     9.136    10.016     0.440     54.50      0.0      1.128     2.128     5.797
 20    53.40     53.40     9.120    10.016     0.448     53.40      0.0      1.128     2.128     5.782
 21    52.60     52.60     9.085    10.016     0.466     52.60      0.0      1.128     2.128     5.746
 22    52.10     52.10     9.054    10.016     0.481     52.10      0.0      1.128     2.128     5.716
 23    52.40     52.40     9.010    10.016     0.503     52.40      0.0      1.128     2.128     5.671
 24    51.60     51.60     8.982    10.016     0.517     51.60      0.0      1.128     2.128     5.644
 25    51.80     51.80     8.982    10.016     0.517     51.80      0.0      1.128     2.128     5.644
 26    52.00     52.00     8.972    10.016     0.522     52.00      0.0      1.128     2.128     5.634
 27    52.50     52.50     8.954    10.016     0.531     52.50      0.0      1.128     2.128     5.615
```

```
SUMMARY OF ESSENTIAL RESULTS STORED IN FILE



 PT   SIGMA1    SIGMA3    STRAIN1    STRAIN3      V

  1    50.06     26.50     1.808     0.148     2.315
  2    57.67     30.50     2.207     0.252     2.301
  3    66.41     35.10     2.835     0.329     2.282
  4    76.39     40.40     3.556     0.503     2.257
  5    87.80     46.50     4.780     0.564     2.225
  6   101.03     53.50     5.967     0.585     2.196
  7   116.27     61.50     7.278     0.704     2.159
  8   133.57     70.80     8.490     0.721     2.130
  9   159.90     84.80    10.360     0.661     2.089
 10    79.73     42.40     9.419     0.320     2.127
 11    79.68     42.40     9.503     0.256     2.128
 12    75.60     44.20     9.503     0.256     2.128
 13    71.90     46.80     9.500     0.258     2.128
 14    68.00     49.20     9.473     0.272     2.128
 15    64.30     51.80     9.427     0.295     2.128
 16    60.50     54.30     9.322     0.347     2.128
 17    56.40     56.40     9.221     0.397     2.128
 18    55.50     55.50     9.156     0.430     2.128
 19    54.50     54.50   · 9.136     0.440     2.128
 20    53.40     53.40     9.120     0.448     2.128
 21    52.60     52.60     9.085     0.466     2.128
 22    52.10     52.10     9.054     0.481     2.128
 23    52.40     52.40     9.010     0.503     2.128
 24    51.60     51.60     8.982     0.517     2.128
 25    51.80     51.80     8.982     0.517     2.128
 26    52.00     52.00     8.972     0.522     2.128
 27    52.50     52.50     8.954     0.531     2.128
```

```
UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

ENERGY CALCULATIONS

****  ENGINEERING STRAIN  ****

SAMPLE NO. = T 716      (REMOULDED SAMPLE)
TEST RESULTS     START     311283      END      140184

 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     50.1       26.5      23.6      34.4      1.808     0.148     2.104      0.0     0.0                 0.0
                                                                                                 0.274
  2     57.7       30.5      27.2      39.6      2.207     0.252     2.710      9.5     0.4                 0.274
                                                                                                 0.440
  3     66.4       35.1      31.3      45.5      2.835     0.329     3.493     20.4     1.1                 0.714
                                                                                                 0.646
  4     76.4       40.4      36.0      52.4      3.556     0.503     4.562     32.9     1.8                 1.360
                                                                                                 1.058
  5     87.8       46.5      41.3      60.3      4.780     0.564     5.909     47.2     3.0                 2.419
                                                                                                 1.142
  6    101.0       53.5      47.5      69.3      5.967     0.585     7.138     63.7     4.2                 3.560
                                                                                                 1.561
  7    116.3       61.5      54.8      79.8      7.278     0.704     8.686     82.7     5.5                 5.121
                                                                                                 1.536
  8    133.6       70.8      62.8      91.7      8.490     0.721     9.932    104.4     6.7                 6.658
                                                                                                 2.651
  9    159.9       84.8      75.1     109.8     10.380     0.661    11.683    137.3     8.6                 9.309
                                                                                                -1.562
 10     79.7       42.4      37.3      54.8      9.419     0.320    10.058     37.2     7.6                 7.747
                                                                                                 0.014
 11     79.7       42.4      37.3      54.8      9.503     0.256    10.016     37.2     7.7                 7.760
                                                                                                 0.0
 12     75.6       44.2      31.4      54.7      9.503     0.256    10.016     35.8     7.7                 7.760
                                                                                                -0.001
 13     71.9       46.8      25.1      55.2      9.500     0.258    10.016     36.1     7.7                 7.759
                                                                                                -0.006
 14     68.0       49.2      18.8      55.5      9.473     0.272    10.016     36.8     7.7                 7.753
                                                                                                -0.007
 15     64.3       51.8      12.5      56.0      9.427     0.295    10.016     38.5     7.6                 7.746
                                                                                                -0.010
 16     60.5       54.3       6.2      56.4      9.322     0.347    10.016     40.7     7.5                 7.736
                                                                                                -0.003
 17     56.4       56.4       0.0      56.4      9.221     0.397    10.016     42.8     7.4                 7.733
                                                                                                 0.0
 18     55.5       55.5       0.0      55.5      9.156     0.430    10.016     41.4     7.4                 7.733
                                                                                                 0.0
 19     54.5       54.5       0.0      54.5      9.136     0.440    10.016     39.8     7.3                 7.733
-----------------------------------------------------------------------------------------------------------------------

                                                                                                 0.0
 20     53.4       53.4       0.0      53.4      9.120     0.448    10.016     38.2     7.3                 7.733
                                                                                                 0.0
 21     52.6       52.6       0.0      52.6      9.085     0.466    10.016     37.0     7.3                 7.733
                                                                                                 0.0
 22     52.1       52.1       0.0      52.1      9.054     0.481    10.016     36.3     7.3                 7.733
                                                                                                 0.0
 23     52.4       52.4       0.0      52.4      9.010     0.503    10.016     36.7     7.2                 7.733
                                                                                                 0.0
 24     51.6       51.6       0.0      51.6      8.982     0.517    10.016     35.5     7.2                 7.733
                                                                                                 0.0
 25     51.8       51.8       0.0      51.8      8.982     0.517    10.016     35.8     7.2                 7.733
                                                                                                 0.0
 26     52.0       52.0       0.0      52.0      8.972     0.522    10.016     36.1     7.2                 7.733
                                                                                                 0.0
 27     52.5       52.5       0.0      52.5      8.954     0.531    10.016     36.9     7.2                 7.733
```

```
UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

ENERGY CALCULATIONS

****     NATURAL STRAIN     ****

SAMPLE NO. : T 716      (REMOULDED SAMPLE)
TEST RESULTS      START     311283      END     140184


 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     50.1      26.5      23.6      34.4     1.825     0.151     2.127       0.0     0.0                 0.0
                                                                                               0.280
  2     57.7      30.5      27.2      39.6     2.232     0.258     2.748       9.5     0.4                 0.280
                                                                                               0.453
  3     66.4      35.1      31.3      45.5     2.876     0.340     3.555      20.4     1.1                 0.734
                                                                                               0.671
  4     76.4      40.4      36.0      52.4     3.621     0.524     4.669      32.9     1.9                 1.405
                                                                                               1.111
  5     87.8      46.5      41.3      60.3     4.898     0.596     6.090      47.2     3.1                 2.516
                                                                                               1.214
  6    101.0      53.5      47.5      69.3     6.152     0.626     7.405      63.7     4.4                 3.730
                                                                                               1.685
  7    116.3      61.5      54.8      79.8     7.556     0.765     9.087      82.7     5.8                 5.415
                                                                                               1.682
  8    133.6      70.8      62.8      91.7     8.873     0.794    10.460     104.4     7.1                 7.097
                                                                                               2.950
  9    159.9      84.8      75.1     109.8    10.937     0.743    12.423     137.3     9.2                10.048
                                                                                              -1.746
 10     79.7      42.4      37.3      54.8     9.893     0.354    10.601      37.2     8.1                 8.301
                                                                                               0.015
 11     79.7      42.4      37.3      54.8     9.986     0.284    10.554      37.2     8.2                 8.316
                                                                                               0.0
 12     75.6      44.2      31.4      54.7     9.986     0.284    10.554      35.8     8.2                 8.316
                                                                                              -0.001
 13     71.9      46.8      25.1      55.2     9.981     0.286    10.554      36.1     8.2                 8.315
                                                                                              -0.007
 14     68.0      49.2      18.8      55.5     9.952     0.301    10.554      36.8     8.1                 8.308
                                                                                              -0.008
 15     64.3      51.8      12.5      56.0     9.901     0.326    10.554      38.5     8.1                 8.301
                                                                                              -0.011
 16     60.5      54.3       6.2      56.4     9.785     0.384    10.554      40.7     8.0                 8.290
                                                                                              -0.003
 17     56.4      56.4       0.0      56.4     9.675     0.440    10.554      42.8     7.9                 8.286
                                                                                               0.0
 18     55.5      55.5       0.0      55.5     9.603     0.476    10.554      41.4     7.8                 8.286
                                                                                              -0.000
 19     54.5      54.5       0.0      54.5     9.580     0.487    10.554      39.8     7.8                 8.286
------------------------------------------------------------------------------------------------------------------------------------

                                                                                              -0.000
 20     53.4      53.4       0.0      53.4     9.563     0.495    10.554      38.2     7.8                 8.286
                                                                                              -0.000
 21     52.6      52.6       0.0      52.6     9.524     0.515    10.554      37.0     7.7                 8.286
                                                                                              -0.000
 22     52.1      52.1       0.0      52.1     9.491     0.532    10.554      36.3     7.7                 8.286
                                                                                              -0.000
 23     52.4      52.4       0.0      52.4     9.442     0.556    10.554      36.7     7.6                 8.286
                                                                                              -0.000
 24     51.6      51.6       0.0      51.6     9.411     0.571    10.554      35.5     7.6                 8.286
                                                                                               0.0
 25     51.8      51.8       0.0      51.8     9.411     0.571    10.554      35.8     7.6                 8.286
                                                                                              -0.000
 26     52.0      52.0       0.0      52.0     9.401     0.577    10.554      36.1     7.6                 8.286
                                                                                               0.0
 27     52.5      52.5       0.0      52.5     9.380     0.587    10.554      36.9     7.6                 8.286
```

```
UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

SAMPLE NO. : T 716      (REMOULDED SAMPLE)

SAMPLE HEIGHT AFTER CONSOLIDATION :  11.831 CENTIMETRES
SAMPLE VOLUME AFTER CONSOLIDATION : 534.285 CUBIC CENTIMETRES
SAMPLE AREA AFTER CONSOLIDATION   :  45.159 SQUARE CENTIMETRES

CONSTANT LOAD                     :   16.50  N .
PROVING RING FACTOR               :  1.2365  N ./DIV
PISTON AREA                       :  5.0700 SQUARE CENTIMETRES

INITIAL DIAL READING              : 1807.70 DIVISIONS


SHEAR TEST RESULTS     START     150184      END     170184


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      PCSTRN  KPA      KPA      STRESS   KPA      STRESS   EFF SIFMA3
                                                                    KPA               KPA

  1   909     1807.7    220.0    199.9    0.0      79.1     42.4     18.3     36.7     54.6      1.865      0.0
  2   920     1804.6    242.0    202.4    0.03     82.8     40.1     21.3     42.7     54.3      2.064      0.42
  3   930     1798.8    259.4    203.9    0.08     85.9     38.5     23.7     47.4     54.3      2.232      0.37
  4   940     1793.1    272.7    205.1    0.12     88.4     37.4     25.5     51.0     54.4      2.365      0.36
  5   950     1786.3    283.8    206.0    0.18     90.5     36.5     27.0     54.0     54.5      2.480      0.35
  6  1000     1778.8    294.5    206.6    0.24     92.6     35.7     28.5     56.9     54.7      2.595      0.33
  7  1010     1772.8    303.9    207.0    0.29     94.7     35.2     29.7     59.5     55.0      2.690      0.31
  8  1020     1764.6    312.0    207.3    0.36     96.7     35.0     30.8     61.7     55.6      2.762      0.30
  9  1030     1758.1    320.0    207.5    0.42     98.6     34.8     31.9     63.8     56.1      2.833      0.28
 10  1040     1750.3    326.7    207.4    0.49    100.3     34.7     32.8     65.6     56.6      2.891      0.26
 11  1050     1743.8    332.6    207.6    0.54    101.8     34.6     33.6     67.2     57.0      2.941      0.25
 12  1100     1735.8    337.0    207.5    0.61    102.9     34.6     34.2     68.3     57.4      2.975      0.24
 13  1115     1722.1    344.0    207.7    0.72    104.8     34.7     35.1     70.1     58.1      3.021      0.23
 14  1130     1710.2    348.6    207.4    0.82    106.5     35.2     35.6     71.3     59.0      3.025      0.22
 15  1145     1697.7    354.0    206.8    0.93    108.1     35.4     36.4     72.7     59.6      3.054      0.19
 16  1200     1684.8    357.2    206.8    1.04    109.2     35.7     36.7     73.5     60.2      3.058      0.19
 17  1215     1667.7    359.2    206.1    1.18    110.1     36.2     37.0     73.9     60.8      3.042      0.17
 18  1230     1656.0    362.1    206.1    1.28    110.8     36.2     37.3     74.6     61.1      3.062      0.16
 19  1245     1643.9    364.4    205.7    1.38    111.6     36.4     37.6     75.2     61.5      3.066      0.15
 20  1300     1630.2    366.5    205.8    1.50    112.3     36.7     37.8     75.6     61.9      3.061      0.15
 21  1320     1611.8    367.9    205.4    1.66    113.0     37.1     37.9     75.9     62.4      3.045      0.14
 22  1340     1592.8    369.0    205.1    1.82    113.5     37.4     38.0     76.1     62.8      3.034      0.13
 23  1400     1573.8    371.8    204.5    1.98    114.4     37.7     38.4     76.7     63.3      3.035      0.11
 24  1420     1554.5    370.2    204.6    2.14    113.9     37.8     38.1     76.1     63.2      3.014      0.12
 25  1440     1537.2    371.3    204.3    2.29    114.3     38.0     38.2     76.3     63.4      3.009      0.11
 26  1500     1517.0    370.8    204.2    2.46    114.2     38.1     38.0     76.1     63.5      2.996      0.11

------------------------------------------------------------------------------------------------------------------

 27  1520     1497.3    370.0    204.2    2.62    113.9     38.2     37.9     75.7     63.4      2.982      0.11
 28  1540     1477.2    370.8    204.3    2.79    113.9     38.1     37.9     75.8     63.4      2.989      0.11
 29  1600     1460.5    371.1    204.4    2.93    113.7     37.9     37.9     75.8     63.2      2.999      0.12
 30  1630     1432.0    372.3    204.3    3.18    113.8     37.9     38.0     75.9     63.2      3.003      0.11
 31  1645     1415.6    370.3    204.3    3.31    113.2     37.9     37.6     75.3     63.0      2.986      0.11
 32  1700     1403.3    368.6    204.6    3.42    112.5     37.8     37.4     74.7     62.7      2.977      0.12
 33  7005     1403.0    366.5    RELAXATION TEST
 34  1701     1402.2    364.4    RELAXATION TEST
 35  1702     1401.8    362.4    RELAXATION TEST
 36  1704     1400.2    360.0    RELAXATION TEST
 37  1708     1398.9    356.5    RELAXATION TEST
 38  1715     1396.5    352.5    RELAXATION TEST
 39  1730     1395.5    348.4    RELAXATION TEST
 40  1800     1394.2    344.1    RELAXATION TEST
 41  1900     1392.8    339.7    RELAXATION TEST
 42  2032     1392.3    335.8    RELAXATION TEST
 43   834     1391.8    329.2    RELAXATION TEST
 44   835     1391.8    329.2    204.5    3.52    102.6     38.4     32.1     64.2     59.8      2.671      0.17
 45   840     1388.6    341.0    206.0    3.54    104.2     36.9     33.6     67.3     59.3      2.823      0.20
 46   850     1384.2    355.4    207.0    3.58    107.0     35.9     35.5     71.1     59.6      2.979      0.21
 47   900     1377.8    366.5    206.5    3.63    109.9     35.9     37.0     74.0     60.6      3.061      0.18
 48   910     1369.3    370.3    206.4    3.71    110.9     36.0     37.5     74.9     61.0      3.082      0.17
 49   920     1360.5    372.4    206.4    3.78    111.5     36.1     37.7     75.4     61.2      3.090      0.17
 50   930     1352.0    373.2    206.1    3.85    112.1     36.5     37.8     75.6     61.7      3.071      0.16
 51   940     1342.5    373.4    205.7    3.93    112.4     36.8     37.8     75.6     62.0      3.054      0.15
 52   950     1332.0    373.0    205.6    4.02    112.4     37.0     37.7     75.4     62.1      3.038      0.15
 53  1000     1322.0    373.5    205.9    4.11    112.2     36.7     37.7     75.5     61.9      3.056      0.15
 54  1015     1309.0    374.5    205.5    4.22    112.7     37.1     37.8     75.6     62.3      3.039      0.14
 55  1030     1295.2    374.4    205.8    4.33    112.1     36.6     37.8     75.5     61.8      3.064      0.15
 56  1045     1280.9    373.7    205.6    4.45    112.1     36.9     37.6     75.2     62.0      3.039      0.15
 57  1100     1266.2    373.2    205.5    4.58    112.0     37.0     37.5     75.0     62.0      3.027      0.15
 58  1120     1249.2    373.0    205.6    4.72    111.7     36.8     37.4     74.9     61.8      3.034      0.15
 59  1140     1228.4    372.8    205.7    4.90    111.6     36.9     37.3     74.7     61.8      3.023      0.15
 60  1200     1208.0    372.6    205.7    5.07    111.1     36.6     37.2     74.5     61.4      3.035      0.15
 61  1228     1178.8    372.2    205.4    5.32    111.3     37.1     37.1     74.2     61.8      2.999      0.15
 62  1300     1149.9    372.2    205.6    5.56    110.9     36.9     37.0     74.0     61.6      3.005      0.15
 63  1332     1116.3    372.1    205.8    5.84    110.4     36.7     36.9     73.7     61.3      3.009      0.16
 64  1400     1090.0    371.0    205.4    6.07    110.1     36.8     36.7     73.3     61.2      2.992      0.15
 65  1430     1064.7    371.1    206.1    6.28    109.5     36.4     36.6     73.1     60.8      3.009      0.17
 66  1549      989.9    371.0    206.3    6.91    109.1     36.5     36.3     72.6     60.7      2.989      0.18
 67  1710      909.8    369.9    205.9    7.59    108.4     36.6     35.9     71.8     60.5      2.962      0.17
 68  1843      826.9    369.8    206.1    8.29    107.5     36.2     35.6     71.3     60.0      2.969      0.18
 69  2020      790.8    369.7    206.3    8.59    107.1     36.1     35.5     71.0     59.8      2.967      0.19
 70   845       89.2    370.6    207.3   14.53    101.9     35.3     33.3     66.6     57.5      2.886      0.25
 71   914       64.0    370.8    207.3   14.74    101.7     35.2     33.2     66.5     57.4      2.888      0.25
 72   934       43.8    369.2    207.5   14.91    100.8     34.8     33.0     66.0     56.8      2.896      0.26
```

```
UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

SAMPLE NO. : T 716      (REMOULDED SAMPLE)

CONSOLIDATION AXIAL STRESS          :    80.00 KPA
PRECONSOLIDATION PRESSURE           :   159.90 KPA
NORMALIZING STRESS                  :   159.90 KPA

NORMALIZED SHEAR TEST RESULTS    START     150184      END     170184

 PT     PER        NRMLZD     EFFECT    NRMLZD     NRMLZD
        CENT       HALF       RATIO     OCT        CHANGE
        PCSTRN     DEV        SIGMA1    STRESS     IN PWP
                   STRESS     SIGMA3    KPA        KPA
                   KPA

  1     0.0        0.115      1.865     0.342      0.0
  2     0.03       0.133      2.064     0.340      0.016
  3     0.08       0.148      2.232     0.340      0.025
  4     0.12       0.160      2.365     0.340      0.033
  5     0.18       0.169      2.480     0.341      0.038
  6     0.24       0.178      2.595     0.342      0.042
  7     0.29       0.186      2.690     0.344      0.044
  8     0.36       0.193      2.762     0.347      0.046
  9     0.42       0.200      2.833     0.351      0.048
 10     0.49       0.205      2.891     0.354      0.047
 11     0.54       0.210      2.941     0.356      0.048
 12     0.61       0.214      2.975     0.359      0.048
 13     0.72       0.219      3.021     0.363      0.049
 14     0.82       0.223      3.025     0.369      0.047
 15     0.93       0.227      3.054     0.373      0.043
 16     1.04       0.230      3.058     0.376      0.043
 17     1.18       0.231      3.042     0.380      0.039
 18     1.28       0.233      3.062     0.382      0.039
 19     1.38       0.235      3.066     0.384      0.036
 20     1.50       0.236      3.061     0.387      0.037
 21     1.66       0.237      3.045     0.390      0.034
 22     1.82       0.238      3.034     0.392      0.033
 23     1.98       0.240      3.035     0.396      0.029
 24     2.14       0.238      3.014     0.395      0.029
 25     2.29       0.239      3.009     0.397      0.028
 26     2.46       0.238      2.996     0.397      0.027
 27     2.62       0.237      2.982     0.397      0.027
 28     2.79       0.237      2.989     0.396      0.028
 29     2.93       0.237      2.999     0.395      0.028
 30     3.18       0.237      3.003     0.395      0.028
 31     3.31       0.235      2.986     0.394      0.028
 32     3.42       0.234      2.977     0.392      0.029
 44     3.52       0.201      2.671     0.374      0.029
 45     3.54       0.210      2.823     0.371      0.038
 46     3.58       0.222      2.879     0.373      0.044
 47     3.63       0.231      3.061     0.379      0.041
---------------------------------------------------------------------------------------------------------

 48     3.71       0.234      3.082     0.381      0.041
 49     3.78       0.236      3.090     0.383      0.041
 50     3.85       0.236      3.071     0.386      0.039
 51     3.93       0.236      3.054     0.388      0.036
 52     4.02       0.236      3.038     0.389      0.036
 53     4.11       0.236      3.056     0.387      0.038
 54     4.22       0.236      3.039     0.390      0.035
 55     4.33       0.236      3.064     0.386      0.037
 56     4.45       0.235      3.039     0.388      0.036
 57     4.58       0.235      3.027     0.388      0.035
 58     4.72       0.234      3.034     0.386      0.036
 59     4.90       0.233      3.023     0.386      0.036
 60     5.07       0.233      3.035     0.384      0.036
 61     5.32       0.232      2.999     0.387      0.034
 62     5.56       0.231      3.005     0.385      0.036
 63     5.84       0.231      3.009     0.383      0.037
 64     6.07       0.229      2.992     0.383      0.034
 65     6.28       0.229      3.009     0.380      0.039
 66     6.91       0.227      2.989     0.380      0.040
 67     7.59       0.225      2.962     0.379      0.038
 68     8.29       0.223      2.969     0.375      0.039
 69     8.59       0.222      2.967     0.374      0.040
 70    14.53       0.208      2.886     0.360      0.046
 71    14.74       0.208      2.888     0.359      0.046
 72    14.91       0.206      2.896     0.355      0.048
```

```
UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

SAMPLE NO. : T 718      (REMOULDED SAMPLE)
INITIAL MOISTURE CONTENT             :   49.2 PERCENT
SPECIFIC GRAVITY OF SOIL             :  2.73
INITIAL VOID RATIO                   :   1.342
INITIAL HEIGHT OF SAMPLE             :  12.67 CM
INITIAL VOLUME OF SAMPLE             :  576.74 CC
EFFECTIVE PRINCIPAL STRESS RATIO     :  1.00
FINAL MOISTURE CONTENT               :   40.8 PERCENT

TX.  CONSOLIDATION    START    210184     END     50284
TRIAXIAL CONSOLIDATION TEST
::::::::::::::::::::::::::::



 PT   EFFECT    EFFECT   STRAIN1    VOLUME   STRAIN3    EFFECT       Q        VOID        V        SHEAR
      SIGMA1    SIGMA3              STRAIN                P                   RATIO                STRAIN

  1    49.89     26.50     1.426     1.942     0.258     34.30     23.39     1.296     2.296     0.779
  2    57.60     30.50     1.730     2.445     0.357     39.53     27.10     1.285     2.285     0.915
  3    66.31     35.10     2.107     3.138     0.515     45.50     31.21     1.268     2.268     1.061
  4    76.42     40.40     3.040     4.473     0.717     52.41     36.02     1.237     2.237     1.549
  5    87.96     46.60     3.856     5.453     0.799     60.39     41.36     1.214     2.214     2.038
  6   101.27     53.60     4.963     6.731     0.884     69.49     47.67     1.184     2.184     2.719
  7   116.48     61.70     6.221     8.080     0.929     79.96     54.78     1.153     2.153     3.528
  8   134.03     71.00     7.575     9.467     0.946     92.01     63.03     1.120     2.120     4.420
  9   160.10     84.80     9.441    11.392     0.975    109.90     75.30     1.075     2.075     5.644
 10    79.70     42.40     8.566     9.900     0.667     54.83     37.30     1.110     2.110     5.266
 11    79.63     42.40     8.620     9.779     0.580     54.81     37.23     1.113     2.113     5.360
 12    75.20     43.80     8.619     9.779     0.580     54.27     31.40     1.113     2.113     5.359
 13    70.90     45.80     8.608     9.779     0.586     54.17     25.10     1.113     2.113     5.348
 14    66.90     48.10     8.584     9.779     0.598     54.37     18.80     1.113     2.113     5.324
 15    62.80     50.30     8.551     9.779     0.614     54.47     12.50     1.113     2.113     5.291
 16    59.00     52.80     8.493     9.779     0.643     54.87      6.20     1.113     2.113     5.234
 17    54.80     54.80     8.430     9.779     0.674     54.80      0.0      1.113     2.113     5.170
 18    53.60     53.60     8.379     9.779     0.700     53.60      0.0      1.113     2.113     5.119
 19    54.70     54.70     8.341     9.779     0.719     54.70      0.0      1.113     2.113     5.081
 20    54.70     54.70     8.323     9.779     0.728     54.70      0.0      1.113     2.113     5.063
 21    53.50     53.50     8.304     9.779     0.738     53.50      0.0      1.113     2.113     5.044
 22    53.80     53.80     8.276     9.779     0.751     53.80      0.0      1.113     2.113     5.017
 23    52.00     52.00     8.275     9.779     0.752     52.00      0.0      1.113     2.113     5.015
 24    53.10     53.10     8.275     9.779     0.752     53.10      0.0      1.113     2.113     5.015
 25    54.10     54.10     8.254     9.779     0.762     54.10      0.0      1.113     2.113     4.994
 26    54.40     54.40     8.212     9.779     0.783     54.40      0.0      1.113     2.113     4.953
 27    54.30     54.30     8.137     9.779     0.821     54.30      0.0      1.113     2.113     4.877
```

```
SUMMARY OF ESSENTIAL RESULTS STORED IN FILE



 PT   SIGMA1    SIGMA3    STRAIN1    STRAIN3      V

  1    49.89     26.50     1.426     0.258     2.296
  2    57.60     30.50     1.730     0.357     2.285
  3    66.31     35.10     2.107     0.515     2.268
  4    76.42     40.40     3.040     0.717     2.237
  5    87.96     46.60     3.856     0.799     2.214
  6   101.27     53.60     4.963     0.884     2.184
  7   116.48     61.70     6.221     0.929     2.153
  8   134.03     71.00     7.575     0.946     2.120
  9   160.10     84.80     9.441     0.975     2.075
 10    79.70     42.40     8.566     0.667     2.110
 11    79.63     42.40     8.620     0.580     2.113
 12    75.20     43.80     8.619     0.580     2.113
 13    70.90     45.80     8.608     0.586     2.113
 14    66.90     48.10     8.584     0.598     2.113
 15    62.80     50.30     8.551     0.614     2.113
 16    59.00     52.80     8.493     0.643     2.113
 17    54.80     54.80     8.430     0.674     2.113
 18    53.60     53.60     8.379     0.700     2.113
 19    54.70     54.70     8.341     0.719     2.113
 20    54.70     54.70     8.323     0.728     2.113
 21    53.50     53.50     8.304     0.738     2.113
 22    53.80     53.80     8.276     0.751     2.113
 23    52.00     52.00     8.275     0.752     2.113
 24    53.10     53.10     8.275     0.752     2.113
 25    54.10     54.10     8.254     0.762     2.113
 26    54.40     54.40     8.212     0.783     2.113
 27    54.30     54.30     8.137     0.821     2.113
```

```
UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

ENERGY CALCULATIONS

****  ENGINEERING STRAIN  ****

SAMPLE NO. : T 718      (REMOULDED SAMPLE)
TEST RESULTS     START    210184      END      50284


 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     49.9      26.5     23.4      34.3     1.426   0.258     1.942     0.0    0.0                0.0
                                                                                         0.220
  2     57.6      30.5     27.1      39.5     1.730   0.357     2.445     9.6    0.3                0.220
                                                                                         0.337
  3     66.3      35.1     31.2      45.5     2.107   0.515     3.138    20.4    0.8                0.557
                                                                                         0.818
  4     76.4      40.4     36.0      52.4     3.040   0.717     4.473    33.0    1.7                1.375
                                                                                         0.742
  5     88.0      46.6     41.4      60.4     3.856   0.799     5.453    47.5    2.5                2.117
                                                                                         1.133
  6    101.3      53.6     47.7      69.5     4.963   0.884     6.731    64.1    3.6                3.250
                                                                                         1.422
  7    116.5      61.7     54.8      80.0     6.221   0.929     8.080    83.1    4.9                4.672
                                                                                         1.718
  8    134.0      71.0     63.0      92.0     7.575   0.946     9.467   105.1    6.2                6.390
                                                                                         2.790
  9    160.1      84.8     75.3     109.9     9.441   0.975    11.392   137.6    8.1                9.180
                                                                                        -1.441
 10     79.7      42.4     37.3      54.8     8.566   0.667     9.900    37.3    7.2                7.739
                                                                                        -0.031
 11     79.6      42.4     37.2      54.8     8.620   0.580     9.779    37.3    7.2                7.707
                                                                                        -0.000
 12     75.2      43.8     31.4      54.3     8.619   0.580     9.779    35.2    7.2                7.707
                                                                                        -0.003
 13     70.9      45.8     25.1      54.2     8.608   0.586     9.779    34.4    7.2                7.704
                                                                                        -0.005
 14     66.9      48.1     18.8      54.4     8.584   0.598     9.779    35.0    7.2                7.699
                                                                                        -0.005
 15     62.8      50.3     12.5      54.5     8.551   0.614     9.779    36.0    7.1                7.693
                                                                                        -0.005
 16     59.0      52.8      6.2      54.9     8.493   0.643     9.779    38.3    7.1                7.688
                                                                                        -0.002
 17     54.8      54.8      0.0      54.8     8.430   0.674     9.779    40.3    7.0                7.686
                                                                                         0.0
 18     53.6      53.6      0.0      53.6     8.379   0.700     9.779    38.5    7.0                7.686
                                                                                         0.0
 19     54.7      54.7      0.0      54.7     8.341   0.719     9.779    40.2    6.9                7.686
-----------------------------------------------------------------------------------------------------------------

                                                                                         0.0
 20     54.7      54.7      0.0      54.7     8.323   0.728     9.779    40.2    6.9                7.686
                                                                                         0.0
 21     53.5      53.5      0.0      53.5     8.304   0.738     9.779    38.4    6.9                7.686
                                                                                         0.0
 22     53.8      53.8      0.0      53.8     8.276   0.751     9.779    38.8    6.9                7.686
                                                                                         0.0
 23     52.0      52.0      0.0      52.0     8.275   0.752     9.779    36.1    6.9                7.686
                                                                                         0.0
 24     53.1      53.1      0.0      53.1     8.275   0.752     9.779    37.8    6.9                7.686
                                                                                         0.0
 25     54.1      54.1      0.0      54.1     8.254   0.762     9.779    39.3    6.9                7.686
                                                                                         0.0
 26     54.4      54.4      0.0      54.4     8.212   0.783     9.779    39.7    6.8                7.686
                                                                                         0.0
 27     54.3      54.3      0.0      54.3     8.137   0.821     9.779    39.6    6.8                7.686
```

```
UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

ENERGY CALCULATIONS

****    NATURAL STRAIN    ****

SAMPLE NO. : T 718      (REMOULDED SAMPLE)
TEST RESULTS     START    210184     END     50284

 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    49.9     26.5    23.4     34.3    1.436    0.262     1.961     0.0    0.0                0.0
                                                                                    0.224
  2    57.6     30.5    27.1     39.5    1.745    0.365     2.475     9.6    0.3               0.224
                                                                                    0.346
  3    66.3     35.1    31.2     45.5    2.130    0.529     3.189    20.4    0.8               0.571
                                                                                    0.846
  4    76.4     40.4    36.0     52.4    3.087    0.745     4.576    33.0    1.8               1.416
                                                                                    0.775
  5    88.0     46.6    41.4     60.4    3.932    0.838     5.607    47.5    2.6               2.192
                                                                                    1.197
  6   101.3     53.6    47.7     69.5    5.090    0.939     6.968    64.1    3.8               3.389
                                                                                    1.523
  7   116.5     61.7    54.8     80.0    6.423    1.001     8.425    83.1    5.1               4.911
                                                                                    1.866
  8   134.0     71.0    63.0     92.0    7.878    1.034     9.945   105.1    6.5               6.777
                                                                                    3.084
  9   160.1     84.8    75.3    109.9    9.917    1.089    12.094   137.6    8.6               9.862
                                                                                   -1.603
 10    79.7     42.4    37.3     54.8    8.955    0.735    10.425    37.3    7.5               8.259
                                                                                   -0.035
 11    79.6     42.4    37.2     54.8    9.014    0.638    10.291    37.3    7.6               8.223
                                                                                   -0.000
 12    75.2     43.8    31.4     54.3    9.013    0.639    10.291    35.2    7.6               8.223
                                                                                   -0.003
 13    70.9     45.8    25.1     54.2    9.001    0.645    10.291    34.4    7.6               8.220
                                                                                   -0.006
 14    66.9     48.1    18.8     54.4    8.975    0.658    10.291    35.0    7.6               8.214
                                                                                   -0.006
 15    62.8     50.3    12.5     54.5    8.939    0.676    10.291    36.0    7.5               8.208
                                                                                   -0.006
 16    59.0     52.8     6.2     54.9    8.876    0.708    10.291    38.3    7.5               8.202
                                                                                   -0.002
 17    54.8     54.8     0.0     54.8    8.807    0.742    10.291    40.3    7.4               8.200
                                                                                   -0.000
 18    53.6     53.6     0.0     53.6    8.751    0.770    10.291    38.5    7.3               8.200
                                                                                   -0.000
 19    54.7     54.7     0.0     54.7    8.709    0.791    10.291    40.2    7.3               8.200
-------------------------------------------------------------------------------------------------------------

                                                                                   -0.000
 20    54.7     54.7     0.0     54.7    8.689    0.801    10.291    40.2    7.3               8.200
                                                                                   -0.000
 21    53.5     53.5     0.0     53.5    8.669    0.811    10.291    38.4    7.3               8.200
                                                                                   -0.000
 22    53.8     53.8     0.0     53.8    8.639    0.826    10.291    38.8    7.2               8.200
                                                                                   -0.000
 23    52.0     52.0     0.0     52.0    8.637    0.827    10.291    36.1    7.2               8.200
                                                                                    0.0
 24    53.1     53.1     0.0     53.1    8.637    0.827    10.291    37.8    7.2               8.200
                                                                                   -0.000
 25    54.1     54.1     0.0     54.1    8.615    0.838    10.291    39.3    7.2               8.200
                                                                                   -0.000
 26    54.4     54.4     0.0     54.4    8.569    0.861    10.291    39.7    7.2               8.200
                                                                                   -0.000
 27    54.3     54.3     0.0     54.3    8.487    0.902    10.291    38.6    7.1               8.200
```

```
UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

SAMPLE NO. = T 718      (REMOULDED SAMPLE)

SAMPLE HEIGHT AFTER CONSOLIDATION :  11.608 CENTIMETRES
SAMPLE VOLUME AFTER CONSOLIDATION : 520.740 CUBIC CENTIMETRES
SAMPLE AREA AFTER CONSOLIDATION   :  44.860 SQUARE CENTIMETRES

CONSTANT LOAD                     :   16.38  N .
PROVING RING FACTOR               :  1.2365  N ./DIV
PISTON AREA                       :  5.0700 SQUARE CENTIMETRES

INITIAL DIAL READING              : 1644.70 DIVISIONS


SHEAR TEST RESULTS    START     60284     END     80284


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      PCSTRN   KPA       KPA       STRESS    KPA       STRESS    EFF SIFMA3
                                                                        KPA                 KPA

  1   814     1644.7    222.6    199.9    0.0       80.1      42.5      18.8      37.6      55.0       1.885        0.0
  2   820     1644.4    235.8    201.2    0.00      82.4      41.2      20.6      41.2      54.9       2.001        0.36
  3   825     1643.0    246.4    202.0    0.01      84.4      40.2      22.1      44.2      54.9       2.099        0.32
  4   830     1640.5    256.0    203.1    0.04      86.1      39.3      23.4      46.8      54.9       2.191        0.35
  5   835     1638.2    263.8    203.7    0.06      87.6      38.6      24.5      49.0      54.9       2.268        0.34
  6   840     1635.2    270.8    204.2    0.08      89.0      38.1      25.4      50.9      55.1       2.335        0.32
  7   850     1629.8    282.7    205.0    0.13      91.5      37.4      27.1      54.1      55.4       2.447        0.31
  8   900     1623.0    294.0    205.6    0.19      93.9      36.7      28.6      57.2      55.8       2.558        0.29
  9   910     1616.0    305.5    206.3    0.25      96.4      36.1      30.2      60.3      56.2       2.671        0.28
 10   920     1609.8    313.7    206.5    0.30      98.3      35.8      31.3      62.5      56.6       2.747        0.26
 11   930     1603.0    322.2    206.9    0.36     100.3      35.5      32.4      64.8      57.1       2.826        0.26
 12   943     1593.2    331.8    206.8    0.44     102.7      35.3      33.7      67.4      57.8       2.911        0.23
 13   950     1588.3    335.6    207.1    0.49     103.7      35.3      34.2      68.4      58.1       2.938        0.23
 14  1000     1580.7    341.0    207.0    0.55     105.1      35.2      34.9      69.9      58.5       2.985        0.22
 15  1016     1567.5    348.1    207.0    0.67     107.0      35.3      35.9      71.7      59.2       3.032        0.21
 16  1030     1555.7    353.8    206.8    0.77     108.7      35.5      36.6      73.2      59.9       3.063        0.19
 17  1045     1540.8    358.2    206.6    0.90     110.0      35.7      37.2      74.3      60.5       3.082        0.18
 18  1100     1528.0    362.0    205.7    1.01     111.7      36.4      37.7      75.3      61.5       3.069        0.15
 19  1115     1514.2    365.2    205.6    1.12     112.8      36.7      38.0      76.1      62.1       3.073        0.15
 20  1130     1502.0    368.5    205.3    1.23     113.8      36.9      38.4      76.9      62.5       3.084        0.14
 21  1145     1487.2    371.0    205.0    1.36     114.7      37.2      38.7      77.5      63.0       3.083        0.13
 22  1200     1471.8    372.8    204.8    1.49     115.3      37.4      38.9      77.9      63.4       3.082        0.12
 23  1215     1459.4    374.8    204.4    1.60     116.1      37.8      39.2      78.3      63.9       3.072        0.11
 24  1230     1446.7    375.8    204.2    1.71     116.5      38.0      39.2      78.5      64.2       3.066        0.11
 25  1245     1430.5    376.6    204.0    1.85     116.8      38.2      39.3      78.6      64.4       3.058        0.10
 26  1300     1416.0    376.8    203.8    1.97     117.0      38.5      39.3      78.5      64.7       3.040        0.10

-------------------------------------------------------------------------------------------------------------------------

 27  1315     1402.1    377.2    203.6    2.09     117.0      38.4      39.3      78.6      64.6       3.047        0.09
 28  1332     1384.8    378.2    203.5    2.24     117.3      38.6      39.4      78.7      64.8       3.040        0.09
 29  1345     1373.8    377.9    203.3    2.33     117.6      39.0      39.3      78.6      65.2       3.014        0.08
 30  1400     1360.4    378.1    203.3    2.45     117.5      39.0      39.3      78.5      65.2       3.013        0.08
 31  1415     1345.5    378.4    203.4    2.58     117.4      38.9      39.2      78.5      65.1       3.018        0.09
 32  1430     1333.7    381.0    203.6    2.68     117.8      38.7      39.6      79.1      65.1       3.044        0.09
 33  1500     1303.8    380.8    203.2    2.94     117.8      38.9      39.4      78.9      65.2       3.027        0.08
 34  1532     1274.0    381.8    203.3    3.19     117.9      39.0      39.5      78.9      65.3       3.023        0.08
 35  1600     1249.4    382.6    203.3    3.41     117.9      39.0      39.5      78.9      65.3       3.024        0.08
 36  1630     1222.6    382.2    203.0    3.64     117.7      39.0      39.3      78.7      65.2       3.017        0.08
 37  1644     1207.5    378.2    203.0    3.77     116.8      39.3      38.7      77.5      65.1       2.971        0.08
 38  1645     1207.5    378.2    RELAXATION TEST
 39  4530     1206.2    375.0    RELAXATION TEST
 40  1646     1205.8    373.2    RELAXATION TEST
 41  1647     1205.1    371.2    RELAXATION TEST
 42  1649     1203.2    368.2    RELAXATION TEST
 43  1653     1203.8    365.2    RELAXATION TEST
 44  1700     1202.8    362.0    RELAXATION TEST
 45  1715     1202.6    357.4    RELAXATION TEST
 46  1745     1196.2    352.9    RELAXATION TEST
 47  1845     1193.2    347.8    RELAXATION TEST
 48  2143     1190.5    339.4    RELAXATION TEST
 49   830     1190.0    331.5    RELAXATION TEST
 50   830     1190.0    331.5    204.3    3.92     103.8      38.8      32.4      64.9      60.5       2.668        0.16
 51   840     1188.5    354.2    206.0    3.93     108.3      37.4      35.4      70.9      61.0       2.895        0.18
 52   850     1182.8    368.0    206.8    3.98     110.9      36.4      37.3      74.5      61.2       3.047        0.19
 53   900     1175.8    375.6    206.9    4.04     112.8      36.3      38.3      76.5      61.8       3.108        0.18
 54   910     1166.8    380.8    206.7    4.12     114.3      36.5      38.9      77.8      62.4       3.131        0.17
 55   920     1160.2    383.9    206.4    4.17     115.4      36.9      39.3      78.5      63.1       3.129        0.16
 56   930     1149.2    385.8    206.4    4.27     115.9      36.9      39.5      79.0      63.2       3.140        0.16
 57   940     1138.0    386.0    206.0    4.37     116.2      37.2      39.5      79.0      63.5       3.122        0.15
 58   950     1130.8    385.2    206.0    4.43     115.8      37.1      39.4      78.7      63.3       3.121        0.15
 59  1000     1119.7    385.2    205.4    4.52     116.4      37.8      39.3      78.6      64.0       3.080        0.13
 60  1017     1104.7    385.3    205.4    4.65     116.3      37.8      39.3      78.5      64.0       3.078        0.13
 61  1032     1090.0    383.8    205.0    4.78     116.2      38.2      39.0      78.0      64.2       3.043        0.13
 62  1045     1080.2    385.2    205.1    4.86     116.4      38.1      39.2      78.3      64.2       3.056        0.13
 63  1120     1049.2    384.0    204.6    5.13     116.0      38.2      38.9      77.8      64.1       3.038        0.12
 64  1145     1027.0    384.8    204.9    5.32     116.1      38.2      38.9      77.9      64.2       3.038        0.12
 65  1227      985.4    383.2    204.6    5.68     115.5      38.3      38.6      77.2      64.0       3.015        0.12
 66  1301      953.0    383.0    204.3    5.96     115.3      38.4      38.5      76.9      64.0       3.003        0.11
 67  1344      913.2    381.9    204.1    6.30     114.7      38.3      38.2      76.4      63.8       2.994        0.11
 68  1425      873.0    380.4    203.9    6.65     114.1      38.4      37.9      75.7      63.6       2.972        0.10
 69  1500      836.0    379.2    203.7    6.97     113.6      38.4      37.6      75.2      63.5       2.958        0.10
 70  1555      782.3    380.0    203.9    7.43     113.2      38.2      37.5      75.0      63.2       2.964        0.11
 71  1728      694.2    379.6    204.0    8.19     112.4      38.1      37.1      74.3      62.9       2.950        0.11
 72  1843      623.9    378.4    204.1    8.79     111.4      37.9      36.8      73.5      62.4       2.940        0.12
 73  2050      501.5    378.4    204.0    9.85     110.7      38.0      36.3      72.7      62.2       2.912        0.12
 74   807     -129.8    378.4    206.1   15.29     104.3      36.0      34.1      68.3      58.8       2.896        0.20
 75   852     -175.7    377.8    205.2   15.68     104.5      36.7      33.9      67.8      59.3       2.848        0.18
 76   902     -185.2    376.4    205.7   15.76     104.2      36.8      33.7      67.4      59.3       2.831        0.19
```

```
UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

SAMPLE NO. : T 718      (REMOULDED SAMPLE)

CONSOLIDATION AXIAL STRESS        :    79.63 KPA
PRECONSOLIDATION PRESSURE         :   160.10 KPA
NORMALIZING STRESS                :   160.10 KPA

NORMALIZED SHEAR TEST RESULTS    START      60284      END      80284

 PT     PER        NRMLZD     EFFECT   NRMLZD     NRMLZD
        CENT       HALF       RATIO    OCT        CHANGE
        PCSTRN     DEV        SIGMA1   STRESS     IN PWP
                   STRESS     SIGMA3   KPA        KPA
                   KPA

  1     0.0        0.117      1.885    0.344      0.0
  2     0.00       0.129      2.001    0.343      0.008
  3     0.01       0.138      2.099    0.343      0.013
  4     0.04       0.146      2.191    0.343      0.020
  5     0.06       0.153      2.268    0.343      0.024
  6     0.08       0.159      2.335    0.344      0.027
  7     0.13       0.169      2.447    0.346      0.032
  8     0.19       0.179      2.558    0.348      0.036
  9     0.25       0.188      2.671    0.351      0.040
 10     0.30       0.195      2.747    0.354      0.041
 11     0.36       0.202      2.826    0.357      0.044
 12     0.44       0.211      2.911    0.361      0.043
 13     0.49       0.214      2.938    0.363      0.045
 14     0.55       0.218      2.985    0.365      0.044
 15     0.67       0.224      3.032    0.370      0.044
 16     0.77       0.229      3.063    0.374      0.043
 17     0.90       0.232      3.082    0.378      0.042
 18     1.01       0.235      3.069    0.384      0.036
 19     1.12       0.238      3.073    0.388      0.036
 20     1.23       0.240      3.084    0.391      0.034
 21     1.36       0.242      3.083    0.394      0.032
 22     1.49       0.243      3.082    0.396      0.031
 23     1.60       0.245      3.072    0.399      0.028
 24     1.71       0.245      3.066    0.401      0.027
 25     1.85       0.245      3.058    0.402      0.026
 26     1.97       0.245      3.040    0.404      0.024
 27     2.09       0.245      3.047    0.403      0.023
 28     2.24       0.246      3.040    0.405      0.022
 29     2.33       0.245      3.014    0.407      0.021
 30     2.45       0.245      3.013    0.407      0.021
 31     2.58       0.245      3.018    0.406      0.022
 32     2.68       0.247      3.044    0.406      0.023
 33     2.94       0.246      3.027    0.407      0.021
 34     3.19       0.246      3.023    0.408      0.021
 35     3.41       0.247      3.024    0.408      0.021
 36     3.64       0.246      3.017    0.407      0.019

----------------------------------------------------------------------------------------------------

 37     3.77       0.242      2.971    0.407      0.019
 50     3.92       0.203      2.668    0.378      0.027
 51     3.93       0.221      2.895    0.381      0.038
 52     3.98       0.233      3.047    0.382      0.043
 53     4.04       0.239      3.108    0.386      0.044
 54     4.12       0.243      3.131    0.390      0.042
 55     4.17       0.245      3.129    0.394      0.041
 56     4.27       0.247      3.140    0.395      0.041
 57     4.37       0.247      3.122    0.397      0.038
 58     4.43       0.246      3.121    0.396      0.038
 59     4.52       0.246      3.080    0.400      0.034
 60     4.65       0.245      3.078    0.400      0.034
 61     4.78       0.244      3.043    0.401      0.032
 62     4.86       0.245      3.056    0.401      0.032
 63     5.13       0.243      3.038    0.401      0.029
 64     5.32       0.243      3.038    0.401      0.031
 65     5.68       0.241      3.015    0.400      0.029
 66     5.96       0.240      3.003    0.400      0.027
 67     6.30       0.239      2.994    0.398      0.026
 68     6.65       0.236      2.972    0.398      0.025
 69     6.97       0.235      2.958    0.396      0.024
 70     7.43       0.234      2.964    0.395      0.025
 71     8.19       0.232      2.950    0.393      0.026
 72     8.79       0.230      2.940    0.390      0.026
 73     9.85       0.227      2.912    0.389      0.026
 74    15.29       0.213      2.896    0.367      0.039
 75    15.68       0.212      2.848    0.370      0.033
 76    15.76       0.210      2.831    0.370      0.036
```

```
UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

SAMPLE NO. : T 720      (REMOULDED SAMPLE)
INITIAL MOISTURE CONTENT           :   50.7 PERCENT
SPECIFIC GRAVITY OF SOIL           :  2.73
INITIAL VOID RATIO                 :   1.385
INITIAL HEIGHT OF SAMPLE           :  12.77 CM
INITIAL VOLUME OF SAMPLE           :  581.20 CC
EFFECTIVE PRINCIPAL STRESS RATIO   :  1.00
FINAL MOISTURE CONTENT             :   42.5 PERCENT

TX.  CONSOLIDATION    START     60184     END    270184
TRIAXIAL CONSOLIDATION TEST
::::::::::::::::::::::::::::



 PT  EFFECT   EFFECT  STRAIN1   VOLUME  STRAIN3   EFFECT      Q       VOID      V      SHEAR
     SIGMA1   SIGMA3            STRAIN               P                RATIO            STRAIN

  1   50.14    26.50    0.952    1.462    0.255    34.38    23.64    1.350    2.350    0.464
  2   57.59    30.50    1.201    1.961    0.380    39.53    27.09    1.338    2.338    0.548
  3   66.22    35.00    1.557    2.598    0.521    45.41    31.22    1.323    2.323    0.691
  4   76.08    40.30    1.997    3.200    0.602    52.23    35.79    1.309    2.309    0.930
  5   87.72    46.40    2.995    4.568    0.787    60.17    41.32    1.276    2.276    1.472
  6  100.98    53.50    4.162    5.927    0.883    69.33    47.48    1.244    2.244    2.186
  7  116.06    61.50    5.453    7.304    0.926    79.69    54.56    1.211    2.211    3.018
  8  133.51    70.70    6.959    8.921    0.981    91.64    62.81    1.172    2.172    3.985
  9  159.97    84.60    8.917   10.831    0.957   109.72    75.37    1.127    2.127    5.306
 10   79.76    42.40    8.075    9.437    0.681    54.85    37.36    1.160    2.160    4.929
 11   79.72    42.40    8.131    9.406    0.638    54.84    37.32    1.161    2.161    4.996
 12   75.90    44.50    8.131    9.406    0.638    54.97    31.40    1.161    2.161    4.996
 13   72.10    47.00    8.122    9.406    0.642    55.37    25.10    1.161    2.161    4.986
 14   68.30    49.50    8.097    9.406    0.655    55.77    18.80    1.161    2.161    4.961
 15   64.50    52.00    8.063    9.406    0.672    56.17    12.50    1.161    2.161    4.928
 16   60.70    54.50    8.018    9.406    0.694    56.57     6.20    1.161    2.161    4.882
 17   57.00    57.00    7.950    9.406    0.728    57.00     0.0     1.161    2.161    4.814
 18   56.80    56.80    7.912    9.406    0.747    56.80     0.0     1.161    2.161    4.776
 19   56.90    56.90    7.870    9.406    0.768    56.90     0.0     1.161    2.161    4.735
 20   56.90    56.90    7.839    9.406    0.784    56.90     0.0     1.161    2.161    4.704
 21   56.60    56.60    7.791    9.406    0.808    56.60     0.0     1.161    2.161    4.656
 22   55.60    55.60    7.782    9.406    0.812    55.60     0.0     1.161    2.161    4.646
 23   56.00    56.00    7.779    9.406    0.814    56.00     0.0     1.161    2.161    4.643
 24   56.30    56.30    7.766    9.406    0.820    56.30     0.0     1.161    2.161    4.631
 25   56.20    56.20    7.704    9.406    0.851    56.20     0.0     1.161    2.161    4.568
 26   56.20    56.20    7.621    9.406    0.893    56.20     0.0     1.161    2.161    4.485
 27   56.90    56.90    7.527    9.406    0.940    56.90     0.0     1.161    2.161    4.392
 28   56.40    56.40    7.487    9.406    0.959    56.40     0.0     1.161    2.161    4.352
 29   54.20    54.20    7.460    9.406    0.973    54.20     0.0     1.161    2.161    4.325
-----------------------------------------------------------------------------------------------------

 30   52.80    52.80    7.433    9.406    0.987    52.80     0.0     1.161    2.161    4.297
 31   49.70    49.70    7.406    9.406    1.000    49.70     0.0     1.161    2.161    4.271
 32   49.40    49.40    7.379    9.406    1.014    49.40     0.0     1.161    2.161    4.244
 32   48.60    48.60    7.354    9.406    1.026    48.60     0.0     1.161    2.161    4.219
```

```
SUMMARY OF ESSENTIAL RESULTS STORED IN FILE


  PT   SIGMA1     SIGMA3     STRAIN1     STRAIN3       V

   1    50.14      26.50      0.952       0.255      2.350
   2    57.58      30.50      1.201       0.380      2.338
   3    66.22      35.00      1.557       0.521      2.323
   4    76.09      40.30      1.997       0.602      2.309
   5    87.72      46.40      2.995       0.787      2.276
   6   100.96      53.50      4.162       0.883      2.244
   7   116.06      61.50      5.453       0.926      2.211
   8   133.51      70.70      6.859       0.981      2.172
   9   159.97      84.60      8.917       0.957      2.127
  10    79.76      42.40      8.075       0.681      2.160
  11    79.72      42.40      8.131       0.638      2.161
  12    75.90      44.50      8.131       0.638      2.161
  13    72.10      47.00      8.122       0.642      2.161
  14    68.30      49.50      8.097       0.655      2.161
  15    64.50      52.00      8.063       0.672      2.161
  16    60.70      54.50      8.018       0.694      2.161
  17    57.00      57.00      7.950       0.728      2.161
  18    56.80      56.80      7.912       0.747      2.161
  19    56.90      56.90      7.870       0.768      2.161
  20    56.90      56.90      7.838       0.784      2.161
  21    56.60      56.60      7.791       0.808      2.161
  22    55.60      55.60      7.782       0.812      2.161
  23    56.00      56.00      7.778       0.814      2.161
  24    56.30      56.30      7.766       0.820      2.161
  25    56.20      56.20      7.704       0.851      2.161
  26    56.20      56.20      7.621       0.893      2.161
  27    56.90      56.90      7.527       0.940      2.161
  28    56.40      56.40      7.487       0.959      2.161
  29    54.20      54.20      7.460       0.973      2.161
  30    52.60      52.60      7.433       0.987      2.161
  31    49.70      49.70      7.406       1.000      2.161
  32    49.40      49.40      7.378       1.014      2.161
  33    46.60      46.60      7.354       1.026      2.161
```

```
UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

ENERGY CALCULATIONS

****  ENGINEERING STRAIN  ****

SAMPLE NO. : T'720      (REMOULDED SAMPLE)
TEST RESULTS     START      60184      END      270184

 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     50.1      26.5     23.6     34.4     0.952    0.255     1.462      0.0      0.0                  0.0
                                                                                            0.208
  2     57.6      30.5     27.1     39.5     1.201    0.380     1.961      9.4      0.3                  0.208
                                                                                            0.312
  3     66.2      35.0     31.2     45.4     1.557    0.521     2.599     20.1      0.7                  0.518
                                                                                            0.374
  4     76.1      40.3     35.8     52.2     1.997    0.602     3.200     32.5      1.2                  0.892
                                                                                            0.978
  5     87.7      46.4     41.3     60.2     2.995    0.787     4.569     48.9      2.2                  1.870
                                                                                            1.197
  6    101.0      53.5     47.5     69.3     4.162    0.883     5.927     63.6      3.3                  3.067
                                                                                            1.450
  7    116.1      61.5     54.6     79.7     5.453    0.926     7.304     82.4      4.6                  4.517
                                                                                            1.953
  8    133.5      70.7     62.8     91.6     6.859    0.981     8.821    104.2      6.1                  6.470
                                                                                            2.835
  9    160.0      84.6     75.4    109.7     8.917    0.957    10.831    137.2      8.0                  9.305
                                                                                           -1.360
 10     79.8      42.4     37.4     54.9     8.075    0.681     9.437     37.2      7.1                  7.945
                                                                                            0.009
 11     79.7      42.4     37.3     54.8     8.131    0.638     9.406     37.2      7.2                  7.954
                                                                                            0.0
 12     75.9      44.5     31.4     55.0     8.131    0.638     9.406     36.2      7.2                  7.954
                                                                                           -0.003
 13     72.1      47.0     25.1     55.4     8.122    0.642     9.406     36.4      7.2                  7.951
                                                                                           -0.006
 14     68.3      49.5     18.8     55.8     8.097    0.655     9.406     37.3      7.2                  7.945
                                                                                           -0.005
 15     64.5      52.0     12.5     56.2     8.063    0.672     9.406     38.8      7.1                  7.940
                                                                                           -0.004
 16     60.7      54.5      6.2     56.6     8.018    0.694     9.406     41.0      7.1                  7.936
                                                                                           -0.002
 17     57.0      57.0      0.0     57.0     7.950    0.728     9.406     43.7      7.0                  7.934
                                                                                            0.0
 18     56.8      56.8      0.0     56.8     7.912    0.747     9.406     43.4      7.0                  7.934
                                                                                            0.0
 19     56.9      56.9      0.0     56.9     7.870    0.768     9.406     43.5      7.0                  7.934
```

20	56.9	56.9	0.0	56.9	7.839	0.784	9.406	43.5	6.9	0.0	7.934
21	56.6	56.6	0.0	56.6	7.791	0.808	9.406	43.1	6.9	0.0	7.934
22	55.6	55.6	0.0	55.6	7.782	0.812	9.406	41.5	6.9	0.0	7.934
23	56.0	56.0	0.0	56.0	7.779	0.814	9.406	42.1	6.8	0.0	7.934
24	56.3	56.3	0.0	56.3	7.766	0.820	9.406	42.6	6.9	0.0	7.934
25	56.2	56.2	0.0	56.2	7.704	0.851	9.406	42.4	6.8	0.0	7.934
26	56.2	56.2	0.0	56.2	7.621	0.893	9.406	42.4	6.7	0.0	7.934
27	56.9	56.9	0.0	56.9	7.527	0.940	9.406	43.5	6.6	0.0	7.934
28	56.4	56.4	0.0	56.4	7.487	0.959	9.406	42.7	6.6	0.0	7.934
29	54.2	54.2	0.0	54.2	7.460	0.973	9.406	39.4	6.6	0.0	7.934
30	52.8	52.8	0.0	52.8	7.433	0.987	9.406	37.3	6.6	0.0	7.934
31	49.7	49.7	0.0	49.7	7.406	1.000	9.406	32.8	6.5	0.0	7.934
32	49.4	49.4	0.0	49.4	7.379	1.014	9.406	32.4	6.5	-0.000	7.934
33	48.6	48.6	0.0	48.6	7.354	1.028	9.406	31.3	6.6	0.000	7.934

UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

ENERGY CALCULATIONS

****   NATURAL STRAIN   ****

SAMPLE NO. : T 720   (REMOULDED SAMPLE)
TEST RESULTS   START   60184   END   270184

PT	EFFECT SIGMA1 KPA	EFFECT SIGMA3 KPA	DEV STRESS KPA	EFFECT OCT STRESS KPA	AXIAL STRAIN %	RADIAL STRAIN %	VOL STRAIN %	LSSV KPA	LSNV %	DELTA ENERGY KJ-M/VOL	TOTAL ENERGY KN-M/VOL
1	50.1	26.5	23.6	34.4	0.955	0.259	1.473	0.0	0.0		0.0
2	57.6	30.5	27.1	39.5	1.209	0.386	1.981	9.4	0.3	0.209	0.209
3	66.2	35.0	31.2	45.4	1.568	0.532	2.632	20.1	0.7	0.318	0.527
4	76.1	40.3	35.8	52.2	2.017	0.618	3.253	32.5	1.2	0.384	0.911
5	87.7	46.4	41.3	60.2	3.041	0.917	4.876	46.9	2.2	1.011	1.922
6	101.0	53.5	47.5	69.3	4.251	0.930	6.110	63.6	3.4	1.254	3.176
7	116.1	61.5	54.6	79.7	5.807	0.889	7.584	82.4	4.8	1.539	4.716
8	133.5	70.7	62.8	91.6	7.213	1.066	9.344	104.2	6.4	2.106	6.821
9	160.0	84.6	75.4	109.7	9.340	1.062	11.464	137.2	8.5	3.115	9.936
10	79.8	42.4	37.4	54.9	8.419	0.747	9.913	37.2	7.5	-1.503	8.433
11	79.7	42.4	37.3	54.8	8.481	0.699	9.878	37.2	7.6	0.008	8.441
12	75.9	44.5	31.4	55.0	8.481	0.699	9.878	38.2	7.6	0.0	8.441
13	72.1	47.0	25.1	55.4	8.471	0.704	9.878	38.4	7.5	-0.003	8.438
14	68.3	49.5	18.8	55.8	8.443	0.718	9.878	37.3	7.5	-0.006	8.432
15	64.5	52.0	12.5	56.2	8.407	0.736	9.878	38.8	7.5	-0.005	8.427
16	60.7	54.5	6.2	56.6	8.357	0.761	9.878	41.0	7.4	-0.005	8.422
17	57.0	57.0	0.0	57.0	8.283	0.798	9.878	43.7	7.4	-0.002	8.420
18	56.8	56.8	0.0	56.8	8.242	0.818	9.878	43.4	7.3	0.0	8.420
19	56.9	56.9	0.0	56.9	8.197	0.841	9.878	43.5	7.3	-0.000	8.420

20	56.9	56.9	0.0	56.9	8.163	0.855	9.876	43.5	7.3	-0.000	8.420
21	56.6	56.6	0.0	56.6	8.111	0.884	9.876	43.1	7.2	-0.000	8.420
22	55.6	55.6	0.0	55.6	8.101	0.888	9.876	41.5	7.2	-0.000	8.420
23	56.0	56.0	0.0	56.0	8.098	0.890	9.876	42.1	7.2	-0.000	8.420
24	56.3	56.3	0.0	56.3	8.084	0.897	9.876	42.6	7.2	-0.000	8.420
25	56.2	56.2	0.0	56.2	8.016	0.931	9.876	42.4	7.1	-0.000	8.420
26	56.2	56.2	0.0	56.2	7.926	0.976	9.876	42.4	7.0	-0.000	8.420
27	56.9	56.9	0.0	56.9	7.826	1.026	9.876	43.5	7.0	-0.000	8.420
28	56.4	56.4	0.0	56.4	7.782	1.048	9.876	42.7	6.9	-0.000	8.420
29	54.2	54.2	0.0	54.2	7.753	1.063	9.876	39.4	6.9	-0.000	8.420
30	52.8	52.8	0.0	52.8	7.723	1.076	9.876	37.3	6.9	-0.000	8.420
31	49.7	49.7	0.0	49.7	7.694	1.092	9.876	32.8	6.8	-0.000	8.420
32	49.4	49.4	0.0	49.4	7.666	1.106	9.876	32.4	6.8	-0.000	8.420
33	48.8	48.8	0.0	48.8	7.639	1.120	9.876	31.3	6.8	-0.000	8.420

UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

SAMPLE NO. : T 720 (REMOULDED SAMPLE)

SAMPLE HEIGHT AFTER CONSOLIDATION : 11.780 CENTIMETRES
SAMPLE VOLUME AFTER CONSOLIDATION : 526.278 CUBIC CENTIMETRES
SAMPLE AREA AFTER CONSOLIDATION : 44.675 SQUARE CENTIMETRES

CONSTANT LOAD : 11.25 N .
PROVING RING FACTOR : 1.2365 N ./DIV
PISTON AREA : 2.8500 SQUARE CENTIMETRES

INITIAL DIAL READING : 1819.80 DIVISIONS

SHEAR TEST RESULTS START 280184 END 300184

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

PT	TIME	DISPL DIAL RDG	PRING DIAL RDG	PORE PRESS KPA	PER CENT PCSTRN	EFFECT SIGMA1 KPA	EFFECT SIGMA3 KPA	HALF DEV STRESS KPA	DEV STRESS KPA	EFFECT OCT STRESS KPA	RATIO OF EFF SIGMA1 EFF SIFMA3	A
1	832	1819.8	183.1	200.1	0.0	80.0	42.3	18.9	37.7	54.9	1.892	0.0
2	840	1817.4	202.0	202.5	0.02	82.9	40.0	21.5	42.9	54.3	2.074	0.46
3	850	1813.0	219.2	204.4	0.06	85.8	38.1	23.8	47.7	54.0	2.252	0.43
4	900	1807.2	232.9	205.8	0.11	88.2	36.7	25.7	51.5	53.9	2.402	0.42
5	910	1800.8	244.4	206.8	0.16	90.4	35.8	27.3	54.6	54.0	2.525	0.40
6	920	1794.2	255.2	207.6	0.22	92.5	35.0	28.8	57.5	54.2	2.644	0.38
7	930	1788.2	265.0	208.4	0.27	94.5	34.3	30.1	60.2	54.4	2.756	0.37
8	940	1779.7	274.7	208.8	0.34	96.8	33.9	31.4	62.9	54.9	2.854	0.35
9	950	1773.1	282.0	208.5	0.40	98.7	33.8	32.4	64.9	55.4	2.919	0.31
10	1000	1765.4	289.8	209.0	0.46	100.2	33.2	33.5	67.0	55.5	3.017	0.30
11	1010	1758.8	296.2	209.3	0.52	101.7	33.0	34.3	68.7	55.9	3.081	0.30
12	1020	1748.8	305.0	209.9	0.60	103.5	32.5	35.5	71.0	56.2	3.186	0.29
13	1030	1740.5	309.1	209.6	0.67	104.8	32.7	36.1	72.1	56.7	3.206	0.28
14	1040	1732.3	315.0	209.6	0.74	106.6	32.9	36.8	73.7	57.5	3.240	0.26
15	1050	1724.0	318.0	209.4	0.81	107.6	33.1	37.2	74.5	57.9	3.249	0.25
16	1100	1715.8	321.8	209.4	0.88	108.5	33.1	37.7	75.4	58.2	3.279	0.25
17	1115	1702.6	326.7	209.2	0.99	110.1	33.4	38.3	76.7	59.0	3.296	0.23
18	1130	1689.1	330.2	209.0	1.11	111.3	33.7	38.8	77.6	59.6	3.301	0.22
19	1145	1674.9	333.5	208.6	1.23	112.5	34.1	39.2	78.4	60.2	3.298	0.21
20	1200	1659.2	333.7	208.1	1.36	112.8	34.5	39.2	78.3	60.6	3.270	0.20
21	1216	1645.2	334.8	207.9	1.48	113.2	34.7	39.3	78.5	60.9	3.263	0.19
22	1230	1632.3	336.2	207.6	1.59	113.8	35.0	39.4	78.8	61.3	3.252	0.18
23	1240	1613.8	338.1	207.3	1.75	114.3	35.1	39.6	79.2	61.5	3.257	0.17
24	1316	1589.7	339.2	207.0	1.95	114.8	35.5	39.7	79.3	61.9	3.235	0.17
25	1340	1567.8	339.7	206.8	2.14	115.1	35.8	39.7	79.3	62.2	3.216	0.16
26	1400	1548.0	339.8	206.6	2.31	115.2	36.0	39.6	79.2	62.4	3.201	0.16
27	1420	1528.8	339.9	206.4	2.47	115.2	36.1	39.6	79.1	62.5	3.192	0.15
28	1440	1512.5	339.8	206.2	2.61	115.3	36.3	39.5	79.0	62.6	3.176	0.15
29	1500	1491.2	339.8	206.3	2.79	114.9	36.1	39.4	78.8	62.4	3.184	0.15
30	1530	1458.2	339.8	206.4	3.07	114.7	36.1	39.3	78.6	62.3	3.177	0.15
31	1559	1432.6	339.7	206.4	3.29	114.5	36.1	39.2	78.4	62.2	3.172	0.15
32	1600	1432.6	339.7	RELAXATION TEST								
33	6030	1430.5	338.0	RELAXATION TEST								
34	1601	1430.0	336.8	RELAXATION TEST								
35	1602	1429.7	334.8	RELAXATION TEST								
36	1604	1429.2	331.8	RELAXATION TEST								
37	1608	1427.8	328.7	RELAXATION TEST								
38	1615	1426.8	324.4	RELAXATION TEST								
39	1630	1425.3	319.5	RELAXATION TEST								
40	1700	1424.8	314.0	RELAXATION TEST								
41	1804	1423.3	307.8	RELAXATION TEST								
42	2004	1421.7	302.4	RELAXATION TEST								
43	856	1420.2	293.1	RELAXATION TEST								
44	900	1420.2	293.1	205.7	3.39	102.4	36.5	32.9	65.9	58.5	2.805	0.20
45	910	1416.4	317.0	208.1	3.42	106.3	34.1	36.1	72.2	58.2	3.119	0.23
46	920	1411.3	331.2	209.2	3.47	109.1	33.1	38.0	76.0	58.4	3.296	0.24
47	930	1404.9	339.2	209.4	3.52	111.0	32.9	39.0	78.1	58.9	3.374	0.23
48	940	1396.7	343.7	209.4	3.59	112.2	33.0	39.6	79.2	59.4	3.401	0.22
49	950	1387.7	346.9	209.4	3.67	113.1	33.1	40.0	80.0	59.8	3.417	0.22
50	1000	1378.7	347.0	208.9	3.74	113.5	33.5	40.0	80.0	60.2	3.388	0.21
51	1015	1364.8	347.7	208.5	3.86	114.1	34.0	40.0	80.1	60.7	3.355	0.20
52	1030	1350.0	347.6	208.2	3.99	114.4	34.5	40.0	79.9	61.1	3.317	0.19
53	1045	1336.4	347.2	208.0	4.10	114.4	34.7	39.9	79.7	61.3	3.297	0.19
54	1103	1318.4	346.3	207.9	4.26	114.2	34.8	39.7	79.4	61.3	3.280	0.19
55	1115	1307.0	345.8	207.9	4.35	113.8	34.7	39.6	79.1	61.1	3.281	0.19
56	1130	1292.8	345.3	207.8	4.47	114.0	35.1	39.4	78.9	61.4	3.248	0.19
57	1145	1278.2	344.6	207.8	4.60	113.7	35.1	39.3	78.6	61.3	3.240	0.19
58	1200	1263.6	343.5	207.9	4.72	113.2	35.0	39.1	78.2	61.1	3.235	0.19
59	1230	1233.8	344.0	207.6	4.97	113.4	35.3	39.1	78.1	61.3	3.214	0.19
60	1300	1217.6	342.8	206.9	5.11	113.6	35.9	38.9	77.7	61.8	3.165	0.17
61	1330	1180.2	342.0	207.0	5.43	112.5	35.2	38.6	77.3	61.0	3.196	0.17
62	1408	1142.8	341.2	206.9	5.75	112.3	35.5	38.4	76.8	61.1	3.164	0.17
63	1507	1088.2	340.0	207.2	6.21	111.5	35.4	38.1	76.1	60.8	3.150	0.19
64	1717	966.8	337.0	207.8	7.24	109.4	34.9	37.2	74.5	59.7	3.134	0.21
65	1756	927.5	335.8	207.8	7.57	108.4	34.5	37.0	73.9	59.1	3.143	0.21
66	1941	832.0	336.5	208.1	8.39	107.9	34.4	36.7	73.5	58.9	3.135	0.22
67	2152	712.2	332.2	208.4	9.40	105.9	34.4	35.8	71.5	58.2	3.080	0.25
68	813	130.2	336.6	209.9	14.34	101.4	32.7	34.4	68.7	55.6	3.101	0.32
69	852	92.5	336.9	210.0	14.66	100.9	32.4	34.3	68.5	55.2	3.115	0.32
70	903	84.2	335.9	210.0	14.73	100.6	32.4	34.1	68.2	55.1	3.106	0.32

```
UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

SAMPLE NO. : T 720     (REMOULDED SAMPLE)

CONSOLIDATION AXIAL STRESS        :   80.00 KPA
PRECONSOLIDATION PRESSURE         :  159.97 KPA
NORMALIZING STRESS                :  159.97 KPA

NORMALIZED SHEAR TEST RESULTS    START    280184     END     300184

 PT      PER       NRMLZD     EFFECT    NRMLZD     NRMLZD
         CENT      HALF       RATIO     OCT        CHANGE
         PCSTRN    DEV        SIGMA1    STRESS     IN PWP
                   STRESS     SIGMA3    KPA        KPA
                   KPA

  1      0.0       0.118      1.892     0.343      0.0
  2      0.02      0.134      2.074     0.340      0.015
  3      0.06      0.149      2.252     0.338      0.027
  4      0.11      0.161      2.402     0.337      0.036
  5      0.16      0.171      2.525     0.338      0.042
  6      0.22      0.180      2.644     0.339      0.047
  7      0.27      0.188      2.756     0.340      0.052
  8      0.34      0.196      2.854     0.343      0.054
  9      0.40      0.203      2.919     0.346      0.053
 10      0.46      0.209      3.017     0.347      0.056
 11      0.52      0.215      3.081     0.349      0.058
 12      0.60      0.222      3.186     0.351      0.061
 13      0.67      0.225      3.206     0.355      0.059
 14      0.74      0.230      3.240     0.359      0.059
 15      0.81      0.233      3.249     0.362      0.058
 16      0.88      0.236      3.279     0.364      0.058
 17      0.99      0.240      3.296     0.369      0.057
 18      1.11      0.242      3.301     0.372      0.056
 19      1.23      0.245      3.298     0.376      0.053
 20      1.36      0.245      3.270     0.379      0.050
 21      1.48      0.245      3.263     0.381      0.049
 22      1.59      0.246      3.252     0.383      0.047
 23      1.75      0.248      3.257     0.384      0.045
 24      1.95      0.248      3.235     0.387      0.043
 25      2.14      0.248      3.216     0.389      0.042
 26      2.31      0.248      3.201     0.390      0.041
 27      2.47      0.247      3.192     0.391      0.039
 28      2.61      0.247      3.176     0.391      0.038
 29      2.79      0.246      3.184     0.390      0.039
 30      3.07      0.246      3.177     0.389      0.039
 31      3.29      0.245      3.172     0.389      0.039
 44      3.39      0.206      2.805     0.365      0.035
 45      3.42      0.226      3.119     0.364      0.050
 46      3.47      0.238      3.296     0.365      0.057
 47      3.52      0.244      3.374     0.368      0.058
 48      3.59      0.248      3.401     0.371      0.058
---------------------------------------------------------------------------------------------------------------------------

 49      3.67      0.250      3.417     0.374      0.058
 50      3.74      0.250      3.388     0.376      0.055
 51      3.86      0.250      3.355     0.379      0.053
 52      3.99      0.250      3.317     0.382      0.051
 53      4.10      0.249      3.297     0.383      0.049
 54      4.26      0.248      3.280     0.383      0.049
 55      4.35      0.247      3.281     0.382      0.049
 56      4.47      0.247      3.248     0.384      0.048
 57      4.60      0.246      3.240     0.383      0.048
 58      4.72      0.244      3.235     0.382      0.049
 59      4.97      0.244      3.214     0.383      0.047
 60      5.11      0.243      3.165     0.386      0.043
 61      5.43      0.242      3.196     0.381      0.043
 62      5.75      0.240      3.164     0.382      0.043
 63      6.21      0.238      3.150     0.380      0.044
 64      7.24      0.233      3.134     0.373      0.048
 65      7.57      0.231      3.143     0.370      0.048
 66      8.39      0.230      3.135     0.368      0.050
 67      9.40      0.224      3.080     0.364      0.052
 68     14.34      0.215      3.101     0.348      0.061
 69     14.66      0.214      3.115     0.345      0.062
 70     14.73      0.213      3.106     0.345      0.062
```

```
UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY


SAMPLE NO. = T 722      (REMOULDED SAMPLE)
INITIAL MOISTURE CONTENT            =   47.1 PERCENT
SPECIFIC GRAVITY OF SOIL            =  2.73
INITIAL VOID RATIO                  =   1.286
INITIAL HEIGHT OF SAMPLE            =  13.04 CM
INITIAL VOLUME OF SAMPLE            =  593.58 CC
EFFECTIVE PRINCIPAL STRESS RATIO    =  0.53
FINAL MOISTURE CONTENT              =   40.6 PERCENT


TX.  CONSOLIDATION    START      10284      END     150284
TRIAXIAL CONSOLIDATION TEST
::::::::::::::::::::::::::::::



 PT   EFFECT     EFFECT   STRAIN1    VOLUME   STRAIN3    EFFECT        Q        VOID        V       SHEAR
      SIGMA1    .SIGMA3              STRAIN                P                  RATIO               STRAIN


  1    50.02      26.50     0.947     1.146     0.099     34.34     23.52     1.260     2.260     0.565
  2    57.50      30.50     1.133     1.373     0.120     39.50     27.00     1.254     2.254     0.676
  3    66.16      35.00     1.411     1.803     0.196     45.39     31.16     1.245     2.245     0.810
  4    76.10      40.30     1.853     2.426     0.287     52.23     35.80     1.230     2.230     1.044
  5    87.63      46.40     2.569     3.353     0.392     60.14     41.23     1.209     2.209     1.452
  6   100.82      53.40     3.679     4.641     0.481     69.21     47.42     1.180     2.180     2.132
  7   115.95      61.40     4.917     5.977     0.530     79.58     54.55     1.149     2.149     2.925
  8   133.45      70.70     6.306     7.502     0.598     91.62     62.75     1.114     2.114     3.805
  9   160.00      84.80     8.198     9.355     0.579    109.87     75.20     1.072     2.072     5.079
 10    79.76      42.40     7.357     7.839     0.241     54.85     37.36     1.107     2.107     4.744
 11    79.71      42.40     7.428     7.800     0.186     54.84     37.31     1.107     2.107     4.828
```

```
SUMMARY OF ESSENTIAL RESULTS STORED IN FILE



 PT   SIGMA1     SIGMA3    STRAIN1    STRAIN3       V


  1    50.02      26.50     0.947      0.099      2.260
  2    57.50      30.50     1.133      0.120      2.254
  3    66.16      35.00     1.411      0.196      2.245
  4    76.10      40.30     1.853      0.287      2.230
  5    87.63      46.40     2.569      0.392      2.209
  6   100.82      53.40     3.679      0.481      2.180
  7   115.95      61.40     4.917      0.530      2.149
  8   133.45      70.70     6.306      0.598      2.114
  9   160.00      84.80     8.198      0.579      2.072
 10    79.76      42.40     7.357      0.241      2.107
 11    79.71      42.40     7.428      0.186      2.107
```

```
UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

ENERGY CALCULATIONS

****  ENGINEERING STRAIN  ****

SAMPLE NO. : T 722       (REMOULDED SAMPLE)
TEST RESULTS     START      10284      END     150284


 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     50.0       26.5      23.5       34.3      0.947     0.099      1.146        0.0      0.0                   0.0
                                                                                                       0.112
  2     57.5       30.5      27.0       39.5      1.133     0.120      1.373        9.4      0.2                   0.112
                                                                                                       0.221
  3     66.2       35.0      31.2       45.4      1.411     0.196      1.803       20.1      0.5                   0.333
                                                                                                       0.383
  4     76.1       40.3      35.8       52.2      1.853     0.287      2.426       32.6      0.9                   0.716
                                                                                                       0.678
  5     87.6       46.4      41.2       60.1      2.569     0.392      3.353       47.0      1.7                   1.393
                                                                                                       1.135
  6    100.8       53.4      47.4       69.2      3.679     0.481      4.641       63.5      2.8                   2.529
                                                                                                       1.398
  7    115.9       61.4      54.6       79.6      4.917     0.530      5.977       82.4      4.0                   3.927
                                                                                                       1.822
  8    133.4       70.7      62.8       91.6      6.306     0.598      7.502      104.2      5.4                   5.748
                                                                                                       2.746
  9    160.0       84.8      75.2      109.9      8.198     0.579      9.355      137.5      7.3                   8.494
                                                                                                      -1.438
 10     79.8       42.4      37.4       54.9      7.357     0.241      7.839       37.3      6.4                   7.056
                                                                                                       0.010
 11     79.7       42.4      37.3       54.8      7.428     0.186      7.800       37.2      6.5                   7.066
```

```
UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

ENERGY CALCULATIONS

****     NATURAL STRAIN     ****

SAMPLE NO. : T 722       (REMOULDED SAMPLE)
TEST RESULTS     START      10284      END     150284


 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     50.0       26.5      23.5       34.3      0.952     0.100      1.152        0.0      0.0                   0.0
                                                                                                       0.113
  2     57.5       30.5      27.0       39.5      1.140     0.121      1.383        9.4      0.2                   0.113
                                                                                                       0.225
  3     66.2       35.0      31.2       45.4      1.421     0.199      1.819       20.1      0.5                   0.338
                                                                                                       0.390
  4     76.1       40.3      35.8       52.2      1.870     0.293      2.456       32.6      1.0                   0.728
                                                                                                       0.696
  5     87.6       46.4      41.2       60.1      2.603     0.404      3.410       47.0      1.7                   1.424
                                                                                                       1.178
  6    100.8       53.4      47.4       69.2      3.749     0.502      4.752       63.5      2.9                   2.602
                                                                                                       1.469
  7    115.9       61.4      54.6       79.6      5.042     0.561      6.163       82.4      4.1                   4.071
                                                                                                       1.943
  8    133.4       70.7      62.8       91.6      6.514     0.642      7.788      104.2      5.6                   6.014
                                                                                                       2.980
  9    160.0       84.8      75.2      109.9      8.553     0.634      9.822      137.5      7.6                   8.994
                                                                                                      -1.568
 10     79.8       42.4      37.4       54.9      7.641     0.261      8.163       37.3      6.7                   7.426
                                                                                                       0.011
 11     79.7       42.4      37.3       54.8      7.718     0.201      8.121       37.2      6.8                   7.437
```

```
UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

SAMPLE NO. = T 722      (REMOULDED SAMPLE)

SAMPLE HEIGHT AFTER CONSOLIDATION =   12.083 CENTIMETRES
SAMPLE VOLUME AFTER CONSOLIDATION = 547.299 CUBIC CENTIMETRES
SAMPLE AREA AFTER CONSOLIDATION   =  45.294 SQUARE CENTIMETRES

CONSTANT LOAD                     =    11.38  N .
PROVING RING FACTOR               =   1.0225  N ./DIV
PISTON AREA                       =   2.8500 SQUARE CENTIMETRES

INITIAL DIAL READING              = 1928.90 DIVISIONS


SHEAR TEST RESULTS     START     150284      END     170284


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      PCSTRN   KPA      KPA      STRESS   KPA      STRESS   EFF SIFMA3
                                                                      KPA               KPA

  1   843     1928.9    302.3    499.8    0.0       79.1     42.5     18.3     36.6     54.7     1.862       0.0
  2   850     1928.1    319.3    501.4    0.01      81.3     40.8     20.2     40.5     54.3     1.992       0.42
  3   855     1927.2    330.1    502.8    0.01      82.5     39.6     21.4     42.9     53.9     2.083       0.48
  4   900     1926.3    344.0    503.8    0.02      84.5     38.5     23.0     46.0     53.8     2.196       0.43
  5   905     1925.2    357.2    504.9    0.03      86.4     37.4     24.5     49.0     53.7     2.311       0.41
  6   910     1924.1    367.2    505.3    0.04      88.1     36.8     25.6     51.3     53.9     2.393       0.38
  7   915     1922.8    376.9    506.5    0.05      89.3     35.8     26.7     53.5     53.6     2.493       0.40
  8   920     1921.5    386.2    507.2    0.06      90.6     35.1     27.8     55.5     53.6     2.582       0.39
  9   925     1919.0    395.2    507.5    0.08      92.4     34.8     28.8     57.6     54.0     2.654       0.37
 10   930     1916.8    402.6    507.7    0.10      93.6     34.4     29.6     59.2     54.1     2.722       0.35
 11   935     1913.9    410.0    508.2    0.12      95.0     34.1     30.4     60.9     54.4     2.785       0.35
 12   940     1910.9    416.8    508.4    0.15      96.3     33.9     31.2     62.4     54.7     2.840       0.33
 13   945     1907.8    422.3    508.5    0.17      97.3     33.7     31.8     63.6     54.9     2.888       0.32
 14   950     1904.5    427.5    508.3    0.20      98.5     33.7     32.4     64.8     55.3     2.923       0.30
 15  1000     1898.2    437.0    508.7    0.25     100.4     33.5     33.4     66.9     55.8     2.996       0.29
 16  1010     1891.2    445.2    508.5    0.31     102.4     33.7     34.3     68.7     56.6     3.038       0.27
 17  1020     1883.2    452.4    508.6    0.38     104.0     33.7     35.1     70.3     57.1     3.085       0.26
 18  1030     1875.0    458.3    508.3    0.45     105.5     34.0     35.8     71.5     57.8     3.104       0.24
 19  1040     1866.8    463.5    508.2    0.51     106.8     34.1     36.3     72.7     58.3     3.131       0.23
 20  1050     1858.2    467.8    508.0    0.59     107.8     34.2     36.8     73.6     58.7     3.151       0.22
 21  1100     1849.8    470.8    507.5    0.65     108.7     34.5     37.1     74.2     59.2     3.151       0.20
 22  1110     1841.2    474.8    507.5    0.73     109.8     34.8     37.5     75.0     59.8     3.156       0.20
 23  1120     1835.3    475.2    507.0    0.77     110.4     35.3     37.5     75.1     60.3     3.127       0.19
 24  1130     1827.5    479.2    507.0    0.84     111.2     35.3     38.0     75.8     60.6     3.151       0.18
 25  1145     1814.6    482.6    506.4    0.95     112.2     35.6     38.3     76.6     61.1     3.152       0.17
 26  1200     1800.8    485.1    506.6    1.06     112.8     35.7     38.5     77.1     61.4     3.159       0.17
-------------------------------------------------------------------------------------------------------------------------
 27  1215     1787.0    487.1    506.5    1.17     113.3     35.9     38.7     77.4     61.7     3.157       0.16
 28  1230     1773.0    488.2    506.6    1.29     113.6     36.0     38.8     77.6     61.9     3.155       0.17
 29  1245     1758.9    489.2    506.3    1.41     114.1     36.4     38.8     77.7     62.3     3.135       0.16
 30  1300     1743.6    490.2    506.0    1.53     114.4     36.6     38.9     77.8     62.5     3.126       0.15
 31  1315     1731.1    491.0    505.8    1.64     114.7     36.8     39.0     77.9     62.8     3.117       0.15
 32  1330     1716.7    491.6    505.7    1.76     114.9     36.9     39.0     78.0     62.9     3.113       0.14
 33  1345     1703.7    492.2    505.6    1.86     115.0     37.0     39.0     78.0     63.0     3.108       0.14
 34  1400     1689.2    492.8    505.3    1.98     115.2     37.1     39.0     78.1     63.1     3.104       0.13
 35  1415     1674.8    493.1    505.4    2.10     115.0     37.0     39.0     78.0     63.0     3.109       0.14
 36  1430     1660.8    493.2    505.4    2.22     115.0     37.0     39.0     78.0     63.0     3.107       0.14
 37  1445     1646.0    493.2    505.0    2.34     115.2     37.3     38.9     77.9     63.3     3.088       0.13
 38  1500     1633.0    493.3    505.1    2.45     115.0     37.2     38.9     77.8     63.1     3.091       0.13
 39  1530     1604.2    493.2    505.0    2.69     114.8     37.2     38.8     77.6     63.1     3.086       0.13
 40  1559     1578.2    491.0    504.9    2.90     114.1     37.2     38.5     76.9     62.8     3.069       0.13
 41  1600     1578.2    491.0    RELAXATION TEST
 42  6030     1577.5    490.2    RELAXATION TEST
 43  1601     1577.2    489.2    RELAXATION TEST
 44  1602     1576.9    487.4    RELAXATION TEST
 45  1604     1576.0    485.1    RELAXATION TEST
 46  1608     1575.1    481.2    RELAXATION TEST
 47  1615     1574.2    476.8    RELAXATION TEST
 48  1630     1572.7    470.8    RELAXATION TEST
 49  1700     1570.8    465.0    RELAXATION TEST
 50  1801     1569.0    459.1    RELAXATION TEST
 51  2000     1567.1    452.8    RELAXATION TEST
 52   847     1563.2    439.3    RELAXATION TEST
 53   850     1563.2    439.3    505.3    3.03     103.2     37.7     32.7     65.5     59.5     2.737       0.19
 54   855     1561.8    451.3    505.2    3.04     105.5     37.4     34.1     68.1     60.1     2.821       0.17
 55   900     1560.2    462.7    506.0    3.05     107.1     36.5     35.3     70.6     60.0     2.935       0.18
 56   910     1555.3    480.8    507.2    3.09     109.9     35.4     37.3     74.5     60.2     3.106       0.20
 57   920     1548.8    491.2    507.4    3.15     112.0     35.2     38.4     76.8     60.8     3.181       0.19
 58   930     1541.2    497.2    507.3    3.21     113.3     35.3     39.0     78.0     61.3     3.210       0.18
 59   940     1532.7    500.0    506.9    3.28     114.3     35.7     39.3     78.6     61.9     3.201       0.17
 60   950     1523.8    501.2    506.4    3.35     114.7     35.9     39.4     78.8     62.2     3.195       0.16
 61  1000     1515.1    501.8    506.3    3.42     115.2     36.3     39.4     78.9     62.6     3.172       0.15
 62  1015     1500.8    501.8    506.1    3.54     115.2     36.4     39.4     78.8     62.7     3.164       0.15
 63  1030     1487.5    501.8    505.9    3.65     115.3     36.6     39.3     78.7     62.8     3.150       0.15
 64  1050     1467.6    501.3    505.5    3.82     115.2     36.8     39.2     78.4     62.9     3.132       0.14
 65  1116     1442.2    500.7    505.7    4.03     114.9     36.8     39.1     78.1     62.8     3.123       0.14
 66  1150     1410.5    499.8    505.8    4.29     114.3     36.6     38.9     77.7     62.5     3.124       0.15
 67  1231     1372.0    498.7    505.8    4.61     113.8     36.6     38.6     77.2     62.3     3.110       0.15
 68  1258     1346.5    498.0    505.8    4.82     113.5     36.6     38.5     76.9     62.2     3.102       0.15
 69  1330     1315.7    497.4    505.7    5.07     113.4     36.8     38.3     76.6     62.3     3.081       0.15
 70  1402     1284.8    496.4    505.6    5.33     113.0     36.8     38.1     76.2     62.2     3.070       0.15
 71  1500     1232.0    495.0    505.6    5.77     112.7     37.2     37.7     75.5     62.4     3.029       0.15
 72  1551     1182.9    493.8    506.3    6.17     111.4     36.5     37.5     74.9     61.5     3.052       0.17
 73  1602     1172.3    493.6    506.3    6.26     111.2     36.4     37.4     74.8     61.3     3.055       0.17
 74  1653     1129.9    495.5    506.3    6.61     111.3     36.4     37.5     74.9     61.4     3.058       0.17
 75  1918      991.1    497.2    506.6    7.76     110.5     36.2     37.2     74.3     61.0     3.054       0.18
 76  2258      784.3    497.1    507.0    9.47     108.7     35.8     36.5     72.9     60.1     3.038       0.20
 77   738      293.6    501.8    507.6   13.53     105.8     35.2     35.3     70.6     58.7     3.006       0.23
 78   804      270.6    501.2    507.4   13.72     105.4     35.1     35.2     70.3     58.5     3.004       0.23
 79   827      247.5    502.2    507.3   13.92     105.5     35.1     35.2     70.4     58.6     3.005       0.22
```

```
UNIVERSITY OF MANITOBA
SOIL MECHANICS LABORATORY

SAMPLE NO. = T 722     (REMOULDED SAMPLE)

CONSOLIDATION AXIAL STRESS        :    79.71 KPA
PRECONSOLIDATION PRESSURE         :   160.00 KPA
NORMALIZING STRESS                :   160.00 KPA

NORMALIZED SHEAR TEST RESULTS    START    150284    END    170284

 PT     PER       NRMLZD    EFFECT   NRMLZD    NRMLZD
        CENT      HALF      RATIO    OCT       CHANGE
        PCSTRN    DEV       SIGMA1   STRESS    IN PWP
                  STRESS    SIGMA3   KPA       KPA
                  KPA

  1     0.0       0.114     1.862    0.342     0.0
  2     0.01      0.126     1.992    0.339     0.010
  3     0.01      0.134     2.083    0.337     0.019
  4     0.02      0.144     2.196    0.337     0.025
  5     0.03      0.153     2.311    0.336     0.032
  6     0.04      0.160     2.393    0.337     0.034
  7     0.05      0.167     2.493    0.335     0.042
  8     0.06      0.174     2.582    0.335     0.046
  9     0.08      0.180     2.654    0.337     0.048
 10     0.10      0.185     2.722    0.338     0.049
 11     0.12      0.190     2.785    0.340     0.052
 12     0.15      0.195     2.840    0.342     0.054
 13     0.17      0.199     2.888    0.343     0.054
 14     0.20      0.202     2.923    0.346     0.053
 15     0.25      0.209     2.996    0.349     0.056
 16     0.31      0.215     3.038    0.354     0.054
 17     0.38      0.220     3.085    0.357     0.055
 18     0.45      0.224     3.104    0.362     0.053
 19     0.51      0.227     3.131    0.364     0.052
 20     0.59      0.230     3.151    0.367     0.051
 21     0.65      0.232     3.151    0.370     0.048
 22     0.73      0.234     3.156    0.374     0.048
 23     0.77      0.235     3.127    0.377     0.045
 24     0.84      0.237     3.151    0.379     0.045
 25     0.95      0.239     3.152    0.382     0.041
 26     1.06      0.241     3.159    0.384     0.043
 27     1.17      0.242     3.157    0.386     0.042
 28     1.29      0.242     3.155    0.387     0.043
 29     1.41      0.243     3.135    0.389     0.041
 30     1.53      0.243     3.126    0.391     0.039
 31     1.64      0.244     3.117    0.392     0.037
 32     1.76      0.244     3.113    0.393     0.037
 33     1.86      0.244     3.108    0.394     0.036
 34     1.98      0.244     3.104    0.394     0.034
 35     2.10      0.244     3.109    0.394     0.035
 36     2.22      0.244     3.107    0.394     0.035
-----------------------------------------------------------------------------------------------

 37     2.34      0.243     3.088    0.395     0.032
 38     2.45      0.243     3.091    0.395     0.033
 39     2.69      0.242     3.086    0.394     0.032
 40     2.90      0.240     3.069    0.393     0.032
 53     3.03      0.205     2.737    0.372     0.034
 54     3.04      0.213     2.821    0.376     0.034
 55     3.05      0.221     2.935    0.375     0.039
 56     3.09      0.233     3.106    0.377     0.046
 57     3.15      0.240     3.181    0.380     0.047
 58     3.21      0.244     3.210    0.383     0.047
 59     3.28      0.246     3.201    0.387     0.044
 60     3.35      0.246     3.195    0.389     0.041
 61     3.42      0.246     3.172    0.391     0.041
 62     3.54      0.246     3.164    0.392     0.039
 63     3.65      0.246     3.150    0.393     0.038
 64     3.82      0.245     3.132    0.393     0.036
 65     4.03      0.244     3.123    0.393     0.037
 66     4.29      0.243     3.124    0.391     0.037
 67     4.61      0.241     3.110    0.390     0.037
 68     4.82      0.240     3.102    0.389     0.037
 69     5.07      0.239     3.081    0.390     0.037
 70     5.33      0.238     3.070    0.389     0.036
 71     5.77      0.236     3.029    0.390     0.036
 72     6.17      0.234     3.052    0.384     0.041
 73     6.26      0.234     3.055    0.383     0.041
 74     6.61      0.234     3.058    0.384     0.041
 75     7.76      0.232     3.054    0.381     0.043
 76     9.47      0.228     3.038    0.376     0.045
 77    13.53      0.221     3.006    0.367     0.049
 78    13.72      0.220     3.004    0.366     0.047
 79    13.92      0.220     3.005    0.366     0.047
```