A CONSTITUTIVE MODEL FOR CREEP OF A FROZEN SAND

By

© Mohammed G. Rahman

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A thesis submitted to the Faculty of Graduate Studies of
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to my family

ABSTRACT

The stress-strain characterictics of frozen sands is nonlinear and time dependent. This thesis develops a constitutive creep model based on time and stress dependent deformation parameters. The general stress state is separated into mean normal and deviatoric components. The associated deformations are volumetric and shear strains. The bulk creep function relates the mean normal stress and the volumetric strain, and the shear creep function relates the deviatoric stress and the shear strain.

Triaxial compression creep tests were carried out on a quartz-carbonate sand at a temperature of -3°C to develop the creep functions. Isotropic compression creep tests were performed to model the bulk creep function as a function of time and mean normal stress. Constant mean normal stress triaxial compression tests were performed to model the shear creep function as a function of time, mean normal stress and deviatoric stress. The two creep functions were then coupled to provide a constitutive creep model applicable to a general stress state.

An assesment of the models developed was made by carrying out a multi-stage constant cell pressure triaxial tests and comparing the values of the axial deformation calculated using the aforementioned constitutive model, with the measured values. The theoretical attenuated axial deformation agreed well with the observed values. The

correlation coefficient was found to be 0.85. The agreement between the predicted and experimental axial strain versus time curves was quite good considering the scatter that was inherent in all test data and the basic assumption made in reconstructing the strain time curves.

A series of short-term constant mean normal stress triaxial compression creep tests were performed to determine whether the onset of dilation was a stress or strain phenomenon. The results from the tests suggested that the onset of dilation was neither singly a strain nor a stress phenomenon but was influenced by both.

A new failure criterion based on the onset of dilation during the creep process was suggested.

The interaction of rigid particles and ice was studied by observing the penetration of rigid steel spheres into ice. The penetration rate was found to be constant under a constant hemispherical stress and was independent of the size of the spheres. A relationship between penetration rate and hemispherical stress was determined.

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LIST OF COMMONLY USED SYMBOLS

A constant in equation (2.4)

a constant in equation (5.10)

B temperature dependent soil parameter

b constant in equation (5.10)

c constant in equations (2.1), (2.8), (5.16) and (8.2)

c dimensionless shape parameter

c cohesion

c_α temperature dependent adhesion at time, $t=\infty$

E elastic modulus

E activation energy

F(Y) constant dependent on activation energy and temperature

f(O) temperature dependent parameter

f strength parameter $f=(1+\sin\Phi)/(1-\sin\Phi)$

G shear modulus

G_c shear creep function

K constant in equation (2.9)

K fitting constant

K bulk modulus

K soil parameter in equation (2.13)

K_c bulk creep function

K_1 parameter dependent on temperature and stress

K_2 parameter dependent on temperature and stress

K_o initial tangent bulk modulus

K_∞ attenuated bulk modulus

L_o initial length of specimen

L_t length of specimen at time, t

m creep exponent

m constant in equations (2.4) and (2.8)

m soil parameter in equation (2.13) and (4.9)

m_1 constant in equation (5.16)

n creep exponent

n constant in equations (2.8), (2.13), (2.16), (4.9) and (8.3)

n_o material constant in equation (2.16)

n(T) material constant

n_1 parameter dependent on stress and temperature

n_2 parameter dependent on stress and temperature

Q activation energy based on strength test

R universal gas constant

S penetration rate

S_d resultant deviatoric stress

S_{ij} deviatoric stress tensor

S_1 deviatoric stress tensor in the direction of σ_1

S_2 deviatoric stress tensor in the direction of σ_2

S_3 deviatoric stress tensor in the direction of σ_3

T absolute temperature ^oK

t time elapsed after load application

t_f time to failure

t_m time to reach minimum creep rate

t^* stress and temperature dependent constant

U activation energy

w soil parameter in equation (2.13)

α constant in equation (5.16)

α_o value of α at $\sigma_m=0$

β reciprocal of the ultimate value of ε_v

β fitting constant

β constant in equation (2.9)

β time dependent constant in equation (2.29)

β_1 material constant in equation (5.16)

β_2 material constant in equation (6.9)

ε axial strain

ε_c creep strain

ε_d resultant deviatoric strain

ε_{ij} strain tensor

ε_{ie} pseudo instantaneous elastic strain

ε_{ip} pseudo instantaneous plastic strain

ε_k arbitrary small strain

ε_{kk} volumetric strain tensor

ε_o instantaneous strain

ε_{oct} octahedral normal strain

ε_m strain at minimum creep strain rate

ε_t strain at time, t

ε_v true volumetric strain

ε_1 true axial strain

ε_2 true lateral strain in the direction of σ_2

ε_3 true lateral strain in the direction of σ_3

$\dot{\varepsilon}$ axial strain rate

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

$\dot{\varepsilon}_c$ creep proof strain rate

$\dot{\varepsilon}_e$ equivalent creep rate

$\dot{\varepsilon}_f$ strain rate at failure

$\dot{\varepsilon}_m$ minimum creep rate

$\dot{\varepsilon}_o$ strain rate at initial time, t=/=0

$\dot{\varepsilon}_p$ plastic strain rate

$\dot{\varepsilon}_v$ volumetric strain rate

ν Poisson's ratio

Φ angle of internal friction

Φ_∞ angle of internal friction at t=∞

σ axial stress

σ hemispherical stress in equation (8.2)

σ deviatoric stress in equation (2.1)

σ_c critical creep strength

σ_c creep proof stress

σ_{cu} value of critical stress at crical strain rate

σ_e equivalent stress

σ_{ij} stress tensor

σ_k temperature dependent deformation modulus

σ_m mean normal stress

σ_m isotropic stress

$\sigma_{n(T)}$ a function of temperature

σ_1 major principal stress

σ_2 intermediate principal stress

σ_3 minor principal stress

θ negetive temperature

θ_o reference temperature

δ_{ij} kronecker delta

CHAPTER ONE
INTRODUCTION

CHAPTER 1

INTRODUCTION

1.1 GENERAL

Frozen soil is a particulate composite material composed of four different constituents: solid mineral or organic grains, ice, unfrozen water, and gases. The most important characteristic by which it differs from unfrozen soil and other particulate materials is that, the matrix which is composed of ice and unfrozen water may change significantly with temperature and pressure. Knowledge of time-dependent stress-strain-strength behaviour of frozen soil is important in design and construction involving naturally occuring and artificially frozen ground. Frozen ground in Canada and other parts of the world has received increasing attention due to the increased development in the permafrost regions of the north.

In the last decade, the Arctic ocean has become of great interest to the petroleum companies, because of the large deposits of oil and natural gases discovered beneath the ocean bottom. The petroleum companies active in the exploration have identified the excessive deformability characteristics of ocean bottom permafrost as one of the major geotechnical problems they face. The ocean bottom permafrost is ice-rich and exists at temperatures that range between $0^{o}C$ and $-3^{o}C$ and is known in the literature as warm permafrost.

Ice-rich frozen soil exhibits large creep strains under a constant stress and to date there is a limited understanding of its behaviour, and there is no reliable model for predicting its behaviour. The creep behaviour is important in the design and construction of structures bearing on either onshore or offshore permafrost, as well as in the use of artificially frozen soil for soil stabilization.

Most of the existing creep theories used to describe the creep behaviour of frozen soils have their roots in the theories originally developed for the plastic and creep deformation of metals. As such they do not include the effects of superimposed hydrostatic stress and consider deformations to be small. The creep theories of metals have been developed using two basic approaches; one is the phenomenological theory and the other is the physical theory. The physical theory, which is based on the established laws of physics is rather complex and has found little use in engineering application. The phenomenological theory, better known as engineering theory is based on the micro-mechanistic behaviour, and provides semi-empirical solutions to engineering problems. In the study of the creep of frozen soils most of the recent research has been centered on engineering theory rather than on the physical theory. There are exceptions such as the studies by Goughnour and Andersland (1968), Chamberlain et al. (1972), Sayles (1973), Vyalov (1973) and Ladanyi (1981) which attempted to take the physical phenomenon into account in the development of empirical solutions.

Most of the existing theories attempted to correlate strain rate with stress, temperature, and some other material properties. Very little effort has been made to evaluate the deformation parameters which relate the stresses and strains. The axial stress-strain data obtained from standard triaxial tests does not represent the true deformation characteristics, because this approach considers only the changes in major principal stress and does not reflect the actual stress conditions in the soil mass. The deformability characterics of frozen soils can perhaps be characterized by bulk and shear creep functions because they can be associated with separate physical components of frozen soil behaviour and can be solved for independently.

1.2 IDENTIFICATION OF THE PROBLEM

The existing creep theories, as discussed in Section 1.1, fail to differentiate between the fundamental behaviour of metal and particulate material like frozen soil. The following specific problems have been identified after review of the literature.

1. The present creep theories do not take superimposed hydrostatic stress into account in their formulation.

2. The present creep theories are based on the notion of no volume change during the creep deformation.

3. The present theories are based on uniaxial tests and the results are then extended to the general state of stress by using equivalent stress and strain relationships.

4. The present theories are based on relatively short term tests using high stresses and the results are extrapolated to predict long term behaviour at low stresses.

5. The deformation parameters relating stresses and strains are not given due importance in formulating the theories.

6. The physical phenomenon of interaction between ice and soil particles is not fully appreciated.

1.3 OBJECTIVES

The general objective of the investigation was to provide a better qualitative understanding of the creep behaviour of frozen soil and to study those aspects, as described in Section 1.2, of creep behaviour that have not been previously investigated so as to generate a more general creep model than the models that are in use today. The specific objectives were :

1. To investigate the influence of the hydrostatic or mean normal stress on the creep behaviour of frozen soil.

2. To measure the volume changes that accompany creep and assess the significance of those volume changes on the creep behaviour.

3. To perform long term creep tests using low stresses which are ordinarily exerted by foundations, as well as high stresses.

4. To obtain solutions for bulk and shear creep functions of a quartz carbonate sand and to generate a constitutive equation and creep model embracing these functions.

5. To examine the interaction between soil particles and ice in an attempt to understand the creep mechanism in frozen soil.

6. To assess the validity of the model by performing standard triaxial compression tests and comparing observed deformations with those predicted by the model.

1.4 SCOPE OF INVESTIGATION

An extensive review of literature on the mechanics of ice and frozen soil was carried out. The review of mechanics of ice included structure of ice in frozen soil, deformation mechanism of ice and quantitative models of strength and deformation of ice. The review of mechanics of frozen soil included structure of frozen soil,

deformational mechanism of frozen soil, effect of mineral particle concentration, confining pressure, temperature and strain rate on strength and deformation of frozen soil. Deformation parameters which relate the stress and strains of nonlinear materials were also reviewed to analyze the stress-strain characteristics of frozen sand.

The approach followed in this study was based on the separation of the stress system into mean normal and deviatoric components. The creep behaviour under changes in hydrostatic stress was studied and the bulk creep function was evaluated based on the data obtained from isotropic compression tests. The creep behaviour under changes in deviatoric stress was studied using triaxial compression tests in which the mean normal stress was kept constant so that all the strains were the result of changes in the deviatoric component of stress only. The shear creep function was evaluated based on the data obtained from the constant mean normal stress triaxial compression tests. The deformation of frozen sand depends to some extent on the interaction of the ice and sand particles. This interaction was studied by applying loads to steel spheres embedded in polycrystalline ice.

In carrying out the experimental investigation, the program was devided into four groups —— 1) multi-stage isotropic consolidation tests, 2) constant mean normal stress multi-stage triaxial tests, 3) constant cell pressure multi-stage triaxial tests and 4) penetration of rigid steel spheres into polycrystalline ice. The sample preparation technique, setting-in procedure and the description of the triaxial equipment are given in Chapter 3. The detailed test procedures are

given in the chapters dealing with each test. The bulk creep function is developed in Chapter 4 and the shear creep function in Chapter 5. A new creep failure criteria is proposed in Chapter 5. Chapter 6 deals with the verification of the model for bulk and shear creep function. The mechanisms of creep deformations are examined in Chapter 7 by comparing the short and long-term test results. The interaction of ice and rigid particle are presented in Chapter 8. Finally the conclusions and recommendations for futher study are given in Chapter 9.

CHAPTER TWO
REVIEW OF MECHANICS OF ICE AND FROZEN SOIL

CHAPTER 2

REVIEW OF MECHANICS OF ICE AND FROZEN SOIL

2.1 MECHANICS OF ICE

2.1.1 Structure of Ice in Frozen Soil

Ice is an important structural component of frozen soil. There are nine different forms of ice as shown in Figure 2.1. The hexagonal structure identified as Ih in Figure 2.1 is the only one which is known to be thermodynamically stable at temperatures between 0°C and -130°C and at atmospheric pressure. The oxygen atoms in ice Ih are arranged in a tetrahedral pattern, each oxygen atom being surrounded by four equally spaced oxygen atoms at the vertices of the tetrahedron. The tetrahedral coordination of the oxygen atoms gives rise to a crystal structure possessing hexagonal symmetry. The molecules form layers of puckered parallel planes known as the basal planes. The normal to the basal plane is referred to as the c-axis of the crystal. There are two hydrogen atoms adjacent to each oxygen atom, but only one hydrogen atom between each pair of oxygen atoms and each molecule is oriented so as to direct its hydrogen atoms towards two of the four neighboring atoms. A unit cell in the crystal structure contains four molecules which correspond to a density of 0.917 Mg/m^3 at 0°C. The basal plane is the demonstrated glide plane of the lattice, and shear applied parallel to

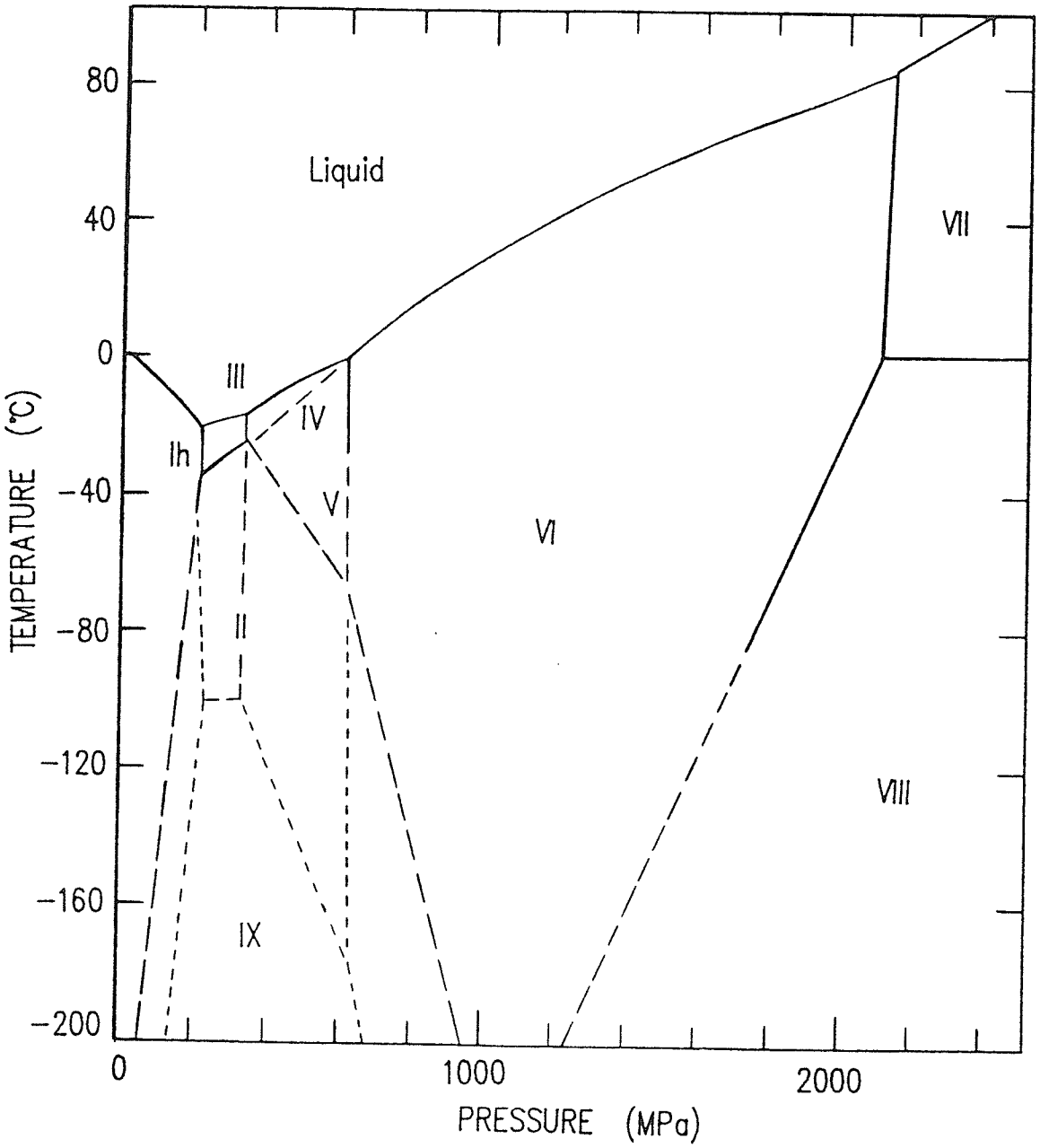


Figure 2.1 Phase diagram for Ice (after Whalley et al. 1968)

this plane gives a strain rate about two orders of magnitude higher than that resulting from shear normal to the basal plane (Mellor, 1979). Higashi (1969) stated that the stress required for nonbasal slip is 10 times greater than that for basal slip. However it has been shown that when attempts are made to produce slip in nonbasal plane directions, ice often fractures before slip occurs (Gold, 1970).

A special property of ice Ih is the mobility of the hydrogen atom in its crystal lattice which changes position under the influence of external disturbances, such as changes in pressure and temperature. The mobility of the hydrogen atom decreases with a lowering of temperature and acquires an organized and stable structure at -78°C (Tsytovich, 1975).

The temperature at which crystallization starts spontaneously could be as low as -40°C for pure water. The condition of supercooling alone is not a sufficient cause for a system to begin crystallization. Before crystals can grow there must exist in the solution a number of minute centres of crystallization. These centres are either the existing ice crystals or some impurities.

Typical natural ice exists in polycrystalline form. The ice, which is an inevitable component of frozen soils, represents a monomineralic cryohydrate materials with highly unique physicomechanical properties that sharply differ from those of other crystalline materials (Tsytovich, 1975). Ice in frozen soil is polycrystalline in nature. The structure of this ice will depend on

soil properties such as grain size, pore size, permeability, specific surface area, surface activity, degree of saturation, amount of impurities and the freezing process.

The axes of the constituent crystals of the polycrystalline ice are randomly oriented and when such ice is stressed the compliance of individual grains varies, depending partly on how the basal planes are oriented relative to the stress field. Under a constant deviatoric stress, recrystallization can take place so as to bring basal planes into closer coincidence with resolved shears, and consequently the crystal orientation ceases to be random and this process is accompanied by strain softening of the sample.

2.1.2 Deformational Mechanisms of Ice

Ice is present in nature at a very high homologous temperature. The effect of temperature in the typical range of 0°C to -20°C is very important because of its strong influence on the unfrozen water content and consequently on the mechanical behaviour of the soil. Polycrystalline ice possesses a unique combination of strength and deformation properties because of the nonsymmetrical behaviour of each of its crystals under stress. Ice exhibits a very time dependent deformational behaviour. It creeps under a very low deviatoric stress and the actual limiting long term strength still remains undetermined. In addition the level of applied stress or the strain rate has appreciable influence on the mechanical behaviour. At sufficiently

high or low levels of either, brittle or ductile failure, respectively, can occur.

Plastic strains in a volume element of a polycrystalline ice are not homogeneous. This inhomogeneous distribution of strains leads to initiation of fracture. Plastic flow occurs by shearing by the process of slip. Slip always occurs by the displacement of blocks of crystals in specific crystallographic directions called slip directions. It usually takes place on particular lattice planes called slip planes or glide planes. Since all atoms on the slip plane do not vibrate in phase with one another, the shearing force that is necessary for atomic displacements will vary from point to point on the same plane. Consequently, slip cannot occur simultaneously with the entire slip plane moving, but it occurs consecutively, beginning in a minute region on the glide plane and spreading outwards. The boundary between the regions where slip has and has not occured is called a dislocation. It is commonly represented by a line on this plane and is called a dislocation line. The element initially containing very few dislocations is able to be strained plastically and the dislocation density increases with strain. Consequently, dislocations multiply when they move.

Polycrystalline ice, which is of particular interest to this study is composed of grains which are randomly oriented with respect to one another. In general, because of the random orientation of the grains, plastic deformation cannot spread easily from one grain to its adjacent grains. Furthermore, the deformation of any one grain cannot

occur independently of its neighbours because, this exerts a constraint effect on the deformation in order that the continuty be maintained at the grain boundary. Due to increase in applied stress, cracking occurs as a result of dislocation pileups at the grain boundaries and stress concentration within the crystals due to defects or impurities. These cracks are transcrystalline and intercrystalline in nature and usually involve one or two grains at a time (Gold, 1966(b), 1970, Hawkes and Mellor, 1972). The propagation of a crack is a brittle phenomenon but the overall appearance is ductile. Hawkes and Mellor (1972) reported that initial cracking occurred at between 2 and 4 MPa at -7°C for polycrystalline snow ice, while Gold (1977), reported that cracking activity started at a stress of about 1 MPa. Gold (1960, 1970) observed formations of microcracks, within a crystal of the aggregate, which were either parallel or perpendicular to the basal plane of the grain. He found the cracks would start to appear only at a certain stress level in compression. They would thus increase during transient creep, but came to a stop if the stress was not exceeded.

Plastic deformation in polycrystalline ice can also occur due to grain boundary sliding, grain boundary migration, phase boundary sliding, or pressure melting at points of high stresses. A deformational mechanism postulated as a function of stress level, temperature and strain rate was developed by Shoji and Higashi, 1978, and is shown in Figure 2.2.

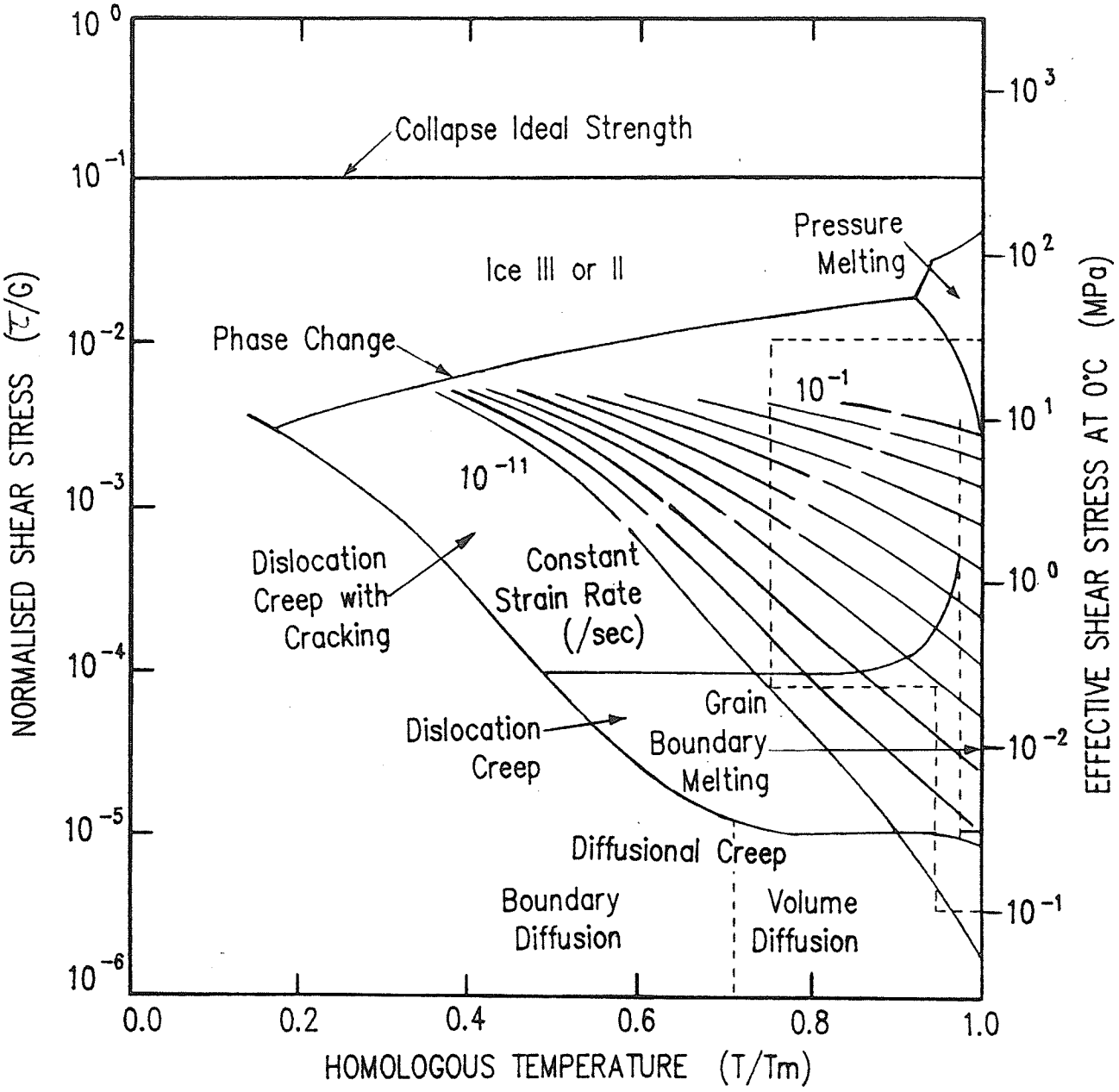


Figure 2.2 Deformation mechanism map for polycrystalline ice of 1mm grain size (after Shoji and Higashi, 1978)

2.1.2.1 Strength of Ice

The strength of a material is usually defined in terms of the maximum stress that can be sustained by the material without failure, when it is loaded at either constant strain rate or constant stress. For ice, this maximum stress is strongly dependent on the strain rate and temperature. Other minor factors such as end restraint conditions, sample shape, structure, grain size and impurities also affect the strength. However, these factors often cause scatter in the test results and make it more difficult to compare results from various sources. It is generally observed that the compressive strength increases with strain rate in the ductile range of the behaviour, but then it reaches a peak and drops to a lower constant value above a strain rate characterized as the ductile/brittle transition (Gold, 1970). Results from stress controlled compression tests on polycrystalline ice at various temperatures,such as those reported by Hawkes and Mellor (1972) shown in Figure 2.3, show strong dependence of uniaxial compressive strength on the applied strain rate.

The uniaxial compressive strength of ice generally increases with a decrease in temperature. The rate of increase depends on the applied strain rate, the other variables remaining constant. Based on the tests by Goughnour and Andersland (1968), the uniaxial compressive strength of ice increases at the rate of 0.14 MPa/^{o}C between -4^{o}C and -12^{o}C at an applied strain rate of 4.4×10^{-6}/sec.

Figure 2.4 shows a typical stress-strain curve for snow ice at -9.5^{o}C subjected to unconfined compressive stress at strain rates

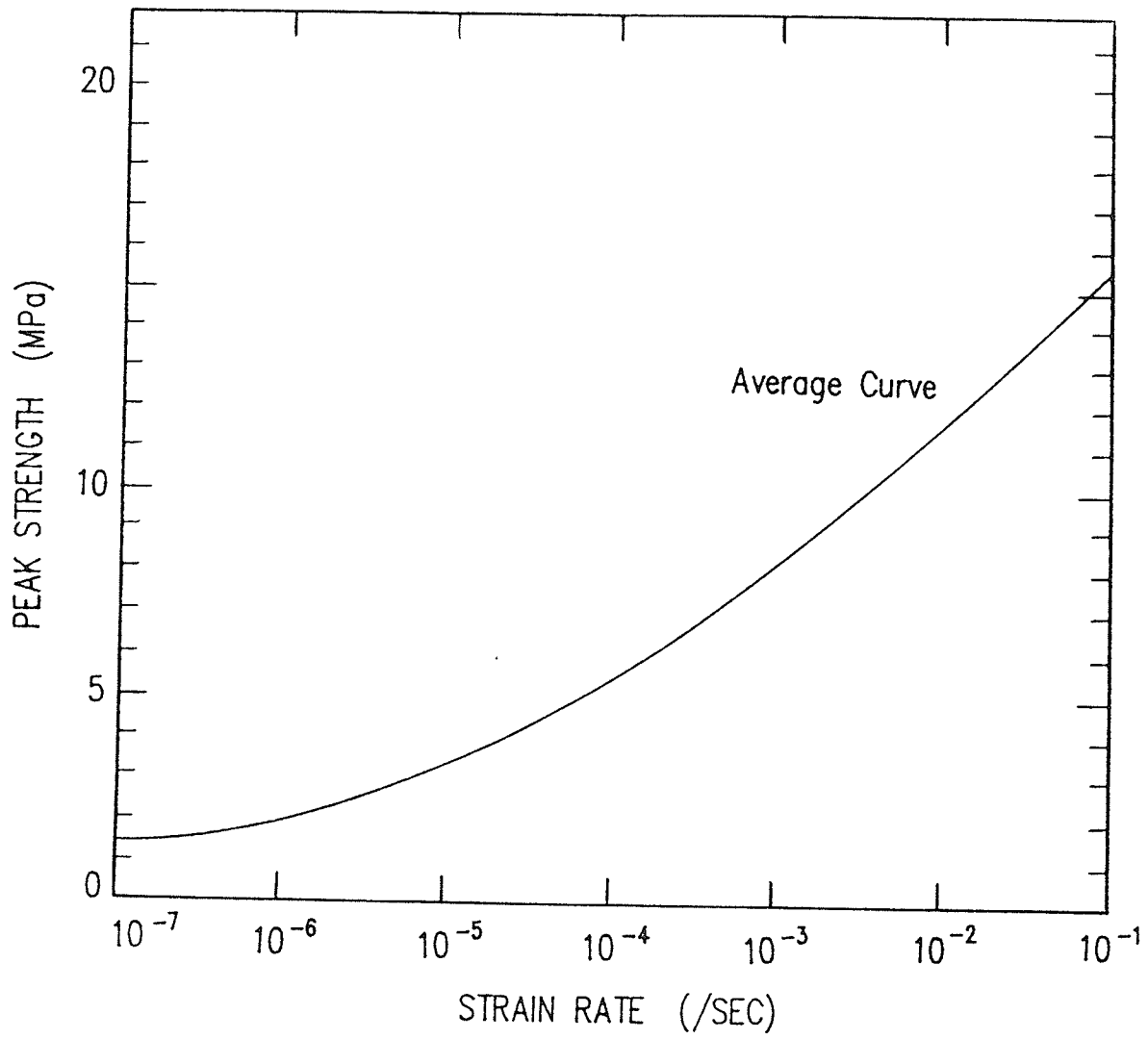


Figure 2.3 Uniaxial compressive strength of ice at −9.5°C (after Ting, 1981)

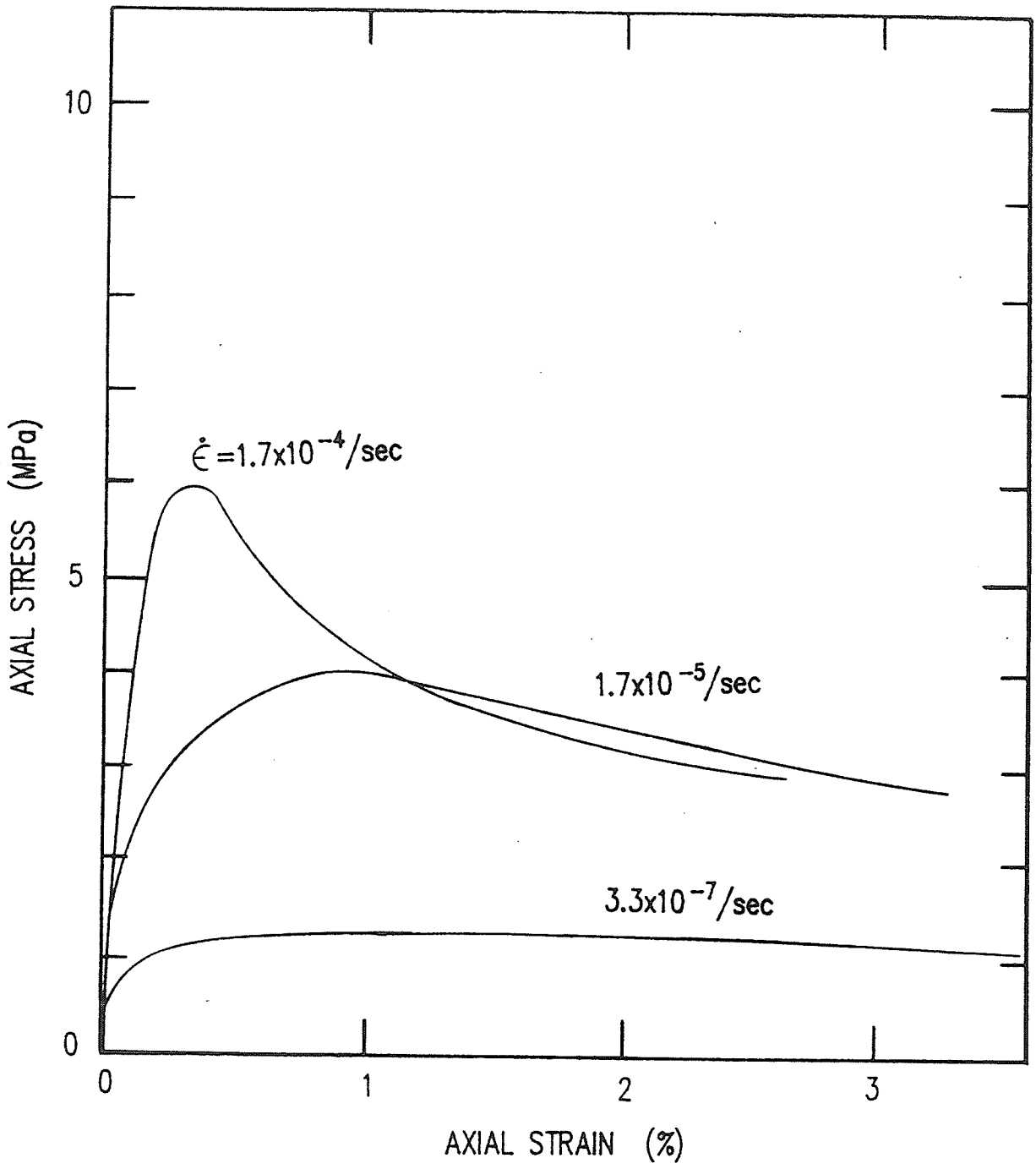


Figure 2.4 Typical stress–strain curves for granular ice at −9.5°C (after Gold and Krausz, 1971)

varying from 10^{-7}/sec to 10^{-4}/sec. It is observed that the peak stress occured at a much lower strain at the higher strain rate and subsequently at the lowest strain rate the stress-strain curves show a smooth transition to a fairly low asymptotic stress with the strain (Gold and Krausz, 1971).

The strength of ice increases with an increase in the concentration of foreign particles. Goughnour and Andersland (1968) observed that peak strength of ice embedded with Ottawa sand increased with an increase in sand concentration as shown in Figure 2.5. The rate of increase in strength rises sharply at a concentration of 42 percent of sand by volume. This was also confirmed by Hooke et al. (1972). This sharp increase is attributed to the interaction of the sand grains.

While most of the strength tests reported in the literature have used uniaxial loading, Sayles (1973), Smith and Cheatham (1975) and Jones (1978) have used triaxial tests and considered the effect of confining stress on the strength. They found an increase in strength with confining stress. Jones (1978) reported that this increase occurred only up to a limiting confining stress of 40 MPa. Strength decreased with further confinement. He suggested that the decrease was due to localized pressure melting. Global pressure melting occurs at a confining stress of about 110 Mpa at -10^{o}C.

The tensile strength of ice is almost independent of temperature and strain rate for strain rates above 10^{-5}/sec (Tsytovich,

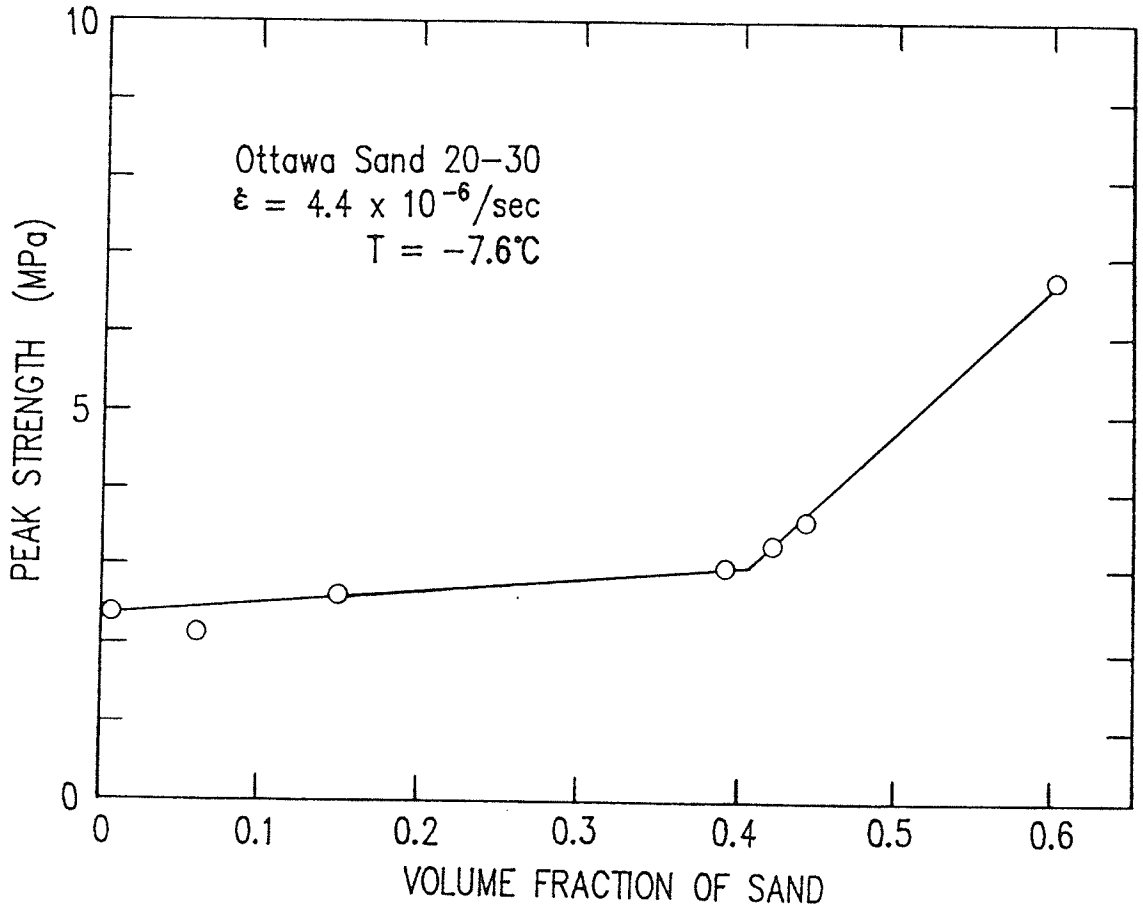


Figure 2.5 Effect of sand concentration on the strength of a sand–ice system (after Goughnour and Andersland, 1968)

1975). In such cases ice fails by brittle fracture with little evidence of internal cracking prior to fracture and separation.

It is generally agreed that the strength of any material increases with an increase in the rate of loading, but the deformation mechanism of ice changes from ductile to brittle at a strain rate known as the transition strain rate and the strength drops abruptly and takes on an asymptotic value. The numerical value of this strain rate again depends on the same factors affecting the strength. At high confining pressure this transition point is suppressed and only ductile behaviour results. Nevertheless, a ductile/brittle transition zone at a strain rate of 10^{-3}/sec has been reported by researchers using uniaxial compressive stress tests (Gold and Krauz, 1971, Jones, 1978).

2.1.2.2 Deformation of Ice

Most of the information on the deformation properties of ice is derived from uniaxial testing either in compression or in tension. Ice exhibits significant elastic, instantaneous permanent, and time-dependent permanent and recoverable deformation under load. The time-dependent permanent deformation contributes a significant portion to the total deformation. If the tests are carried out to sufficiently large strains they display the responses as illustrated in Figure 2.6 where the strain is plotted, on linear scale, as a function of time. The complete strain-time curve displays instantaneous elastic strain, ε_o, decelerating "primary creep", I, transitional "secondary creep", II, and accelerating "tertiary creep",III.

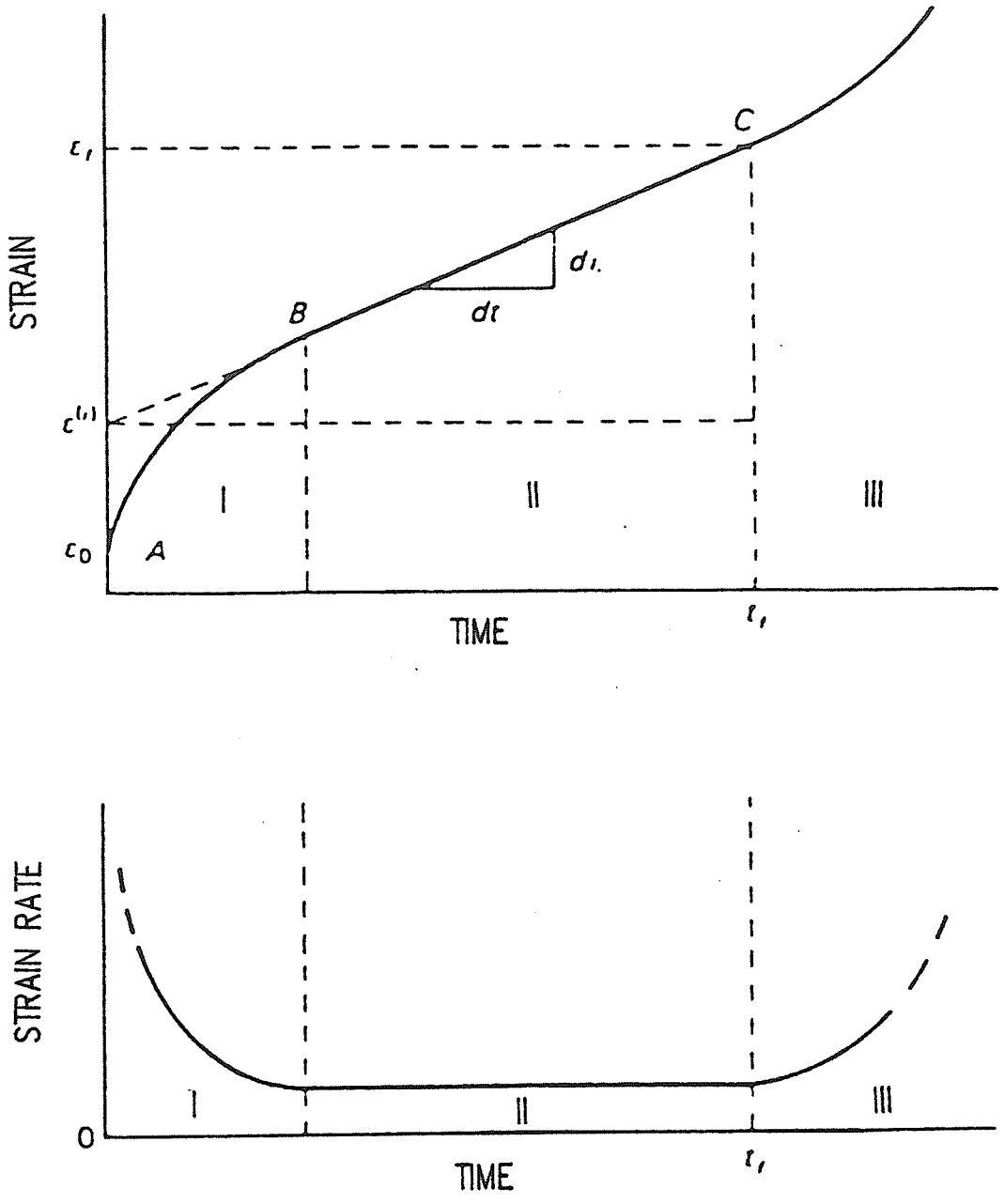


Figure 2.6 Typical creep curves for ice
(a) Strain–Time curve
(b) Strain rate–Time curve

Instantaneous elastic strain is dependent on the Young's modulus of ice. In most of the tests, the stress is applied abruptly at zero time producing an infinite strain rate. It was reported by Mellor (1979) that relatively high stresses applied instantaneously could damage the specimen permanently by developing internal cracks. In a typical creep test, the instantaneous elastic strain is relatively small, in the order of 0.01 percent with a stress of 1 MPa and proportionately less at lower stresses.

Primary creep is a viscoelastic response consisting of a recoverable "delayed elastic" strain and irreversible viscous strain. This stage is characterized by a progressive decrease in the rate of irreversible strain approaching zero as a limit. The primary creep is accompanied by reorientation and recrystallization of the ice with a decrease in sizes of the crystals, consequently increasing the density of ice. If the stress is removed abruptly during the course of the creep test, abrupt recovery of the instantaneous elastic strain and gradual recovery of the delayed elastic strain will occur.

Secondary creep is characterized by a constant rate of deformation. This is accompanied by the closing of microcracks, the decrease in the porosity and the formation of new microcracks. After a certain time equilibrium is reached between the healing of the existing structural defects and the generation of new defects.

Tertiary creep is characterized by the acceleration of the rate of deformation. This stage is accompanied by the development of

microscopic cracks, the appearance of new microscopic cracks at a steadily increasing rate with their transition to macroscopic cracks. This would result in recrystallization and reorientation of the crystals with their basal planes parallel to the shear direction causing a substantial decrease in the shear strength of the ice. Tertiary creep at large strains has not been well studied. However, a reasonable supposition states that acceleration gradually ceases so that strain rate tends asymptotically to a limit (Mellor, 1979).

Almost all the mechanisms of deformation such as microcracking, point and line defect motion, grain boundary sliding, dislocation buildup, crystal orientation and recrystallization exhibit time dependence. Of these deformational mechanisms, some tend to harden while others tend to soften the structure of ice crystals. It is clear from the above that several deformational mechanisms appear to control the creep of ice during the entire time period from initial loading to final rupture.

The creep of ice depends on stress, temperature and sample quality. Most of the previous work in the literature centered on the relationship between minimum creep rate, $\dot{\varepsilon}_m$, and applied stress, σ. Mellor (1979) reported a relationship expressed in the form of $\dot{\varepsilon}_m = A\sigma^n$, where the exponent n is between 3 and 4, and A is a temperature dependent constant. The above expression is good for a stress range of 0.2 to 2 MPa. At higher stress n increases with stress level.

Studies, on the effect of temperature on the creep behaviour of

ice by different researchers, have shown that the creep rate of ice is temperature sensitive at temperatures above -10°C. The strain rate decreases with the decrease in temperature as shown in Figure 2.7. Barnes et al. (1971) concluded that for low stresses, microcreep mechanisms such as point and line defect movement dominated below -10°C, while above this, grain boundary mechanism dominated. Pressure melting and recrystallization become significant at a temperature higher than -3°C.

The effect of grain size of ice on creep has been studied by Jacka (1984), Duval and leGac (1981), Jones and Chew (1981), Baker (1978) and Goodman (1978). Jacka stated that ice crystal size had little or no effect on the minimum flow rate of isotropic polycrystalline ice. It may, however, affect the primary or transient flow rate and thus the time to reach minimum strain rate. As a consequence of dynamic recrystallization during the creep process the mean crystal sizes increase or decrease to an equilibrium size apparently dependent on stress and temperature. Baker (1978) indicated that the strain rate increased markedly with decrease in grain size. Duval and LeGac (1981) and Jones and Chew (1981) disagreed with the results of Baker. Combined plots (Figure 2.8) of Duval et al., Jones et al., Baker and Sego show wide discrepency in measured strain rate for a given grain size while results of each supports their own conclusions.

The particulate impurities in ice has appreciable influence on its deformation behaviour. Hooke et al. (1972) observed that the creep

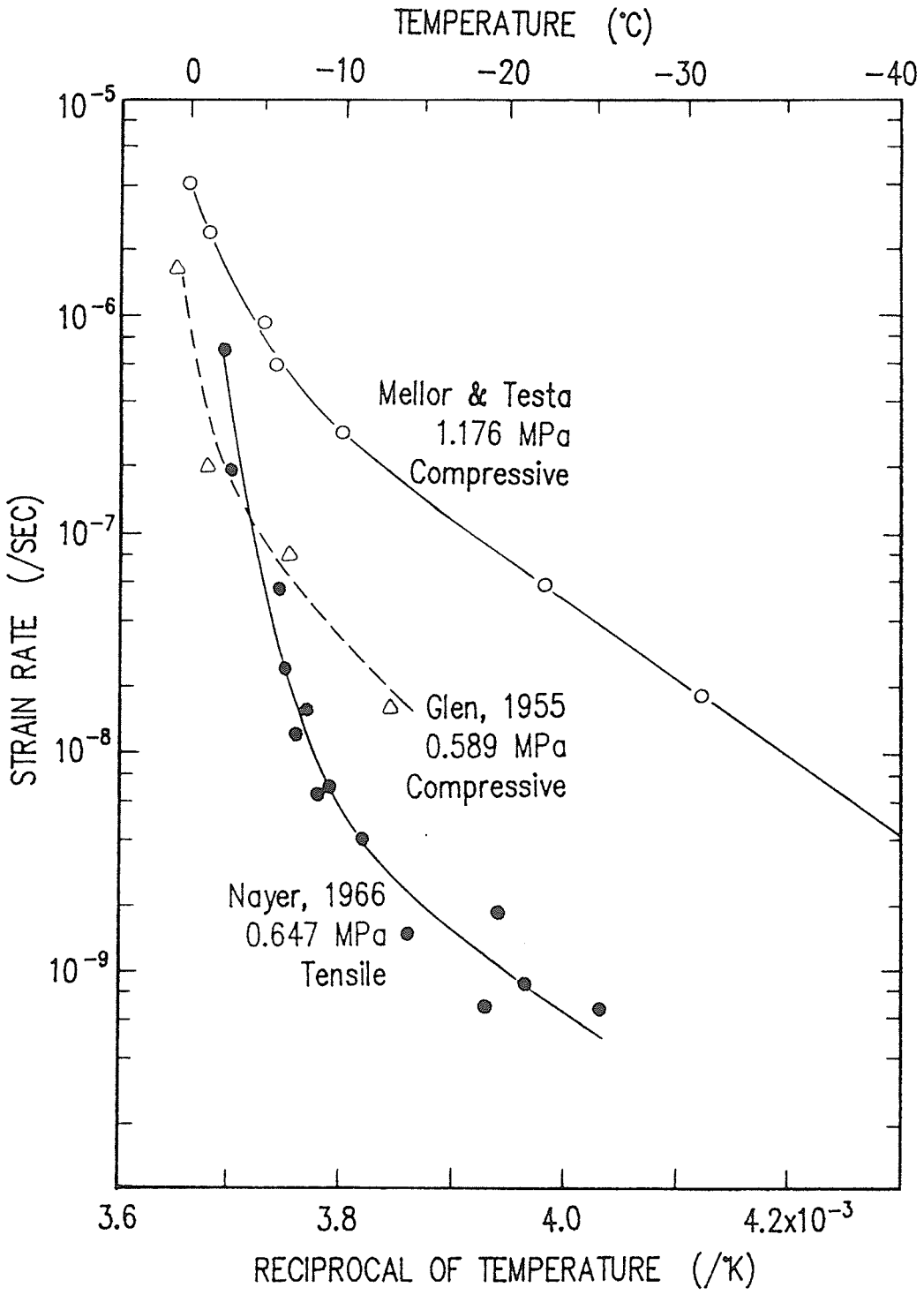


Figure 2.7 Logarithm of strain–rate as a function of temperature for polycrystalline ice (after Barnes et al., 1971)

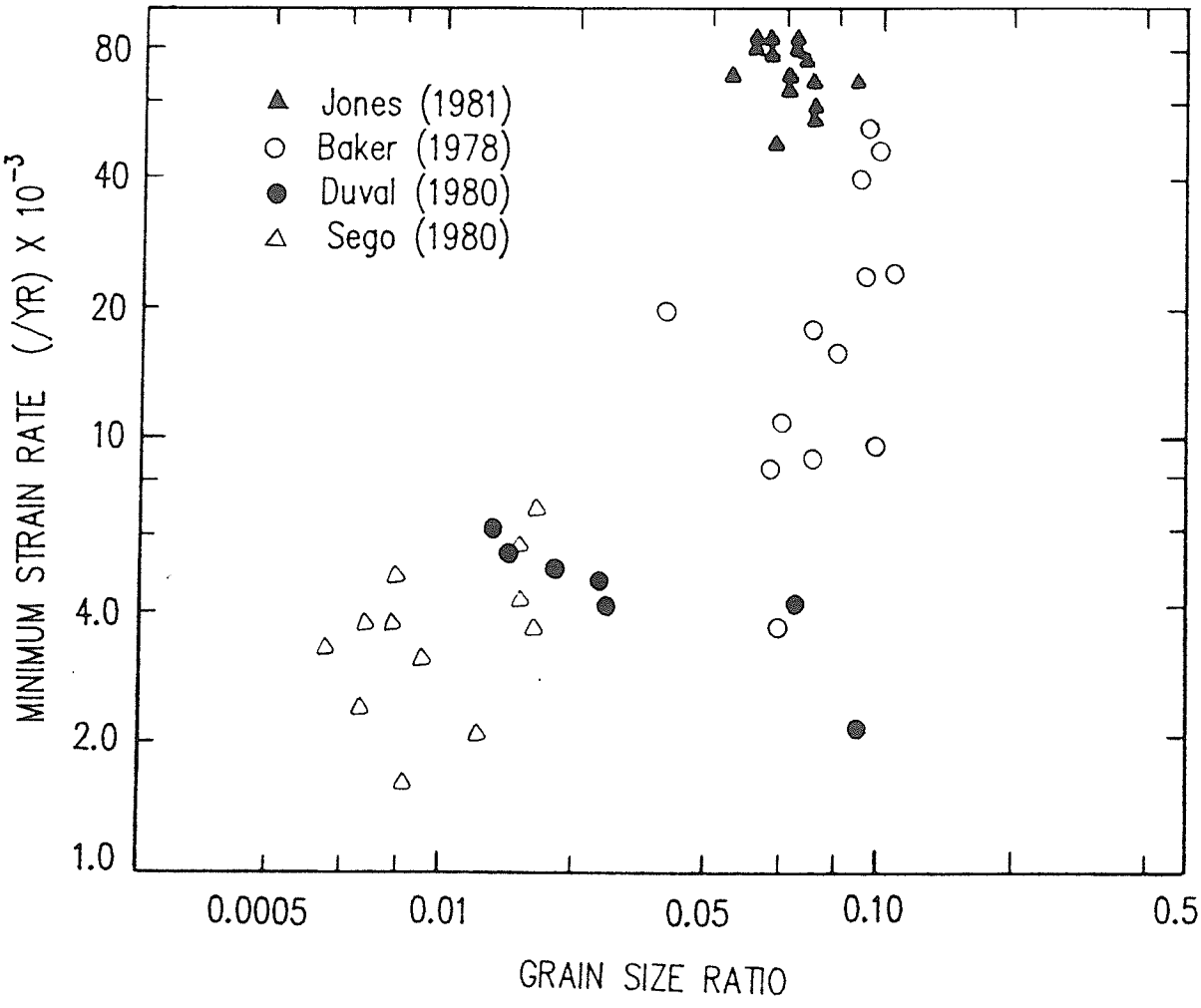


Figure 2.8 Strain rate versus grain size ratio of various authors.

of the ice-sand mixture decreased as the amount of sand increased. The plot of minimum strain rate versus volume of sand fraction in Figure 2.9 indicates that the minimum strain rate decreases with an increase in sand content. This confirms the results obtained by Goughnour and Andersland (1968) presented in Figure 2.5 where the peak strength increased with an increase in volume of sand.

2.1.3 Quantitative Models of Strength and Deformation of Ice

Strength and deformation properties of ice have been studied extensively by various researchers during the last two decades. Large scatter in strength and deformation data is found for nominally identical samples tested under similar test conditions. The scatter in the test results may be attributed to the ice sample, testing apparatus and testing environment.

One of the earliest theories which relates the steady state strain rate,temperature and stress level of ice is the Rate Process Theory formulated by Eyring (1936). Weertman (1973), Langdon (1973) and Gold (1973) have modified the Rate Process Theory equation and wrote it in simpler form :

$$\dot{\varepsilon} = c\sigma^{n} \exp\left(\frac{E}{RT}\right) \qquad (2.1)$$

where $\dot{\varepsilon}$ = steady state strain rate

n, c = constants

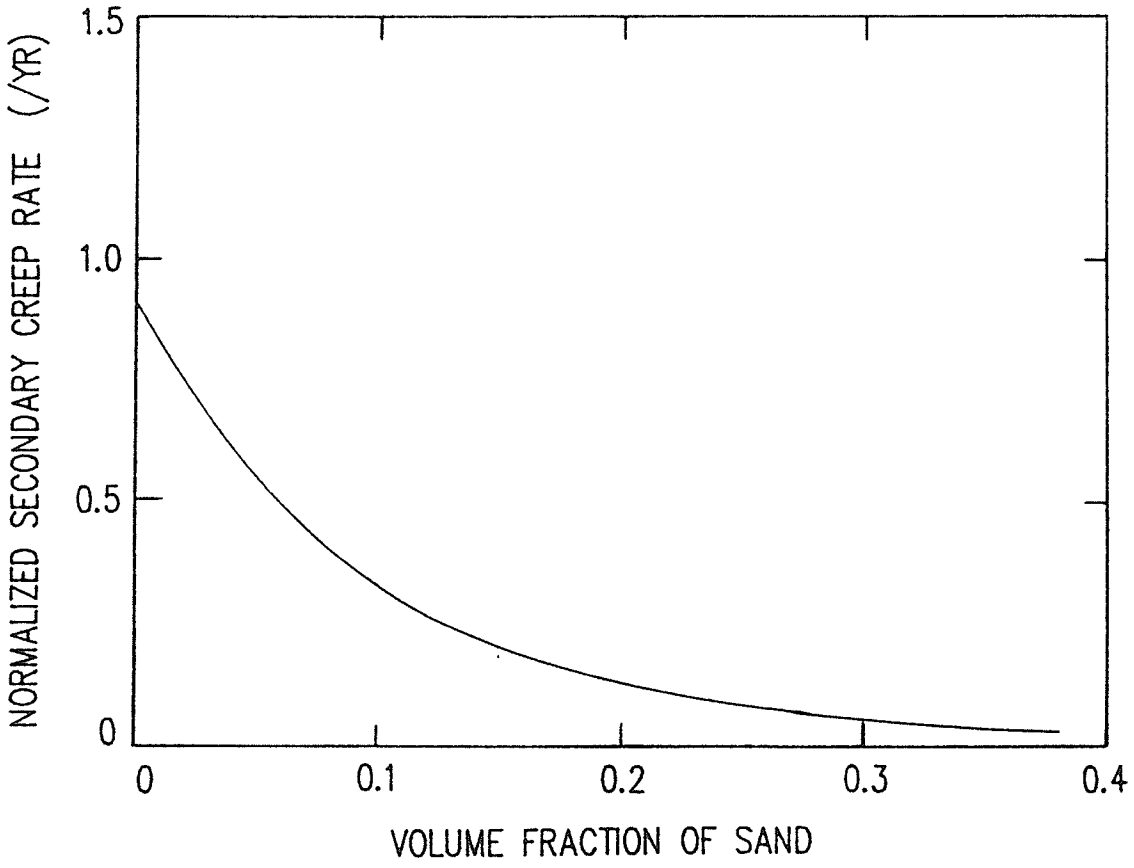


Figure 2.9 Normalized secondary creep rate as a function of volume fraction of sand (after Hooke et al., 1972)

σ = deviatoric stress level

E = activation energy

R = universal gas constant (8.31 J/^{o}K mole)

T = temperature (^{o}K)

Based on the modified Rate Process Theory equation (2.1) was rewritten by Muguruma (1969) in terms of stress :

$$\sigma = c'\dot{\varepsilon}^{1/n} \exp\left(\frac{Q}{nRT}\right) \qquad (2.2)$$

where the value of n varies from 1.3 to 6.7 and Q varies from 42 to 75 K Joules/Mole, as reported by various researchers and summarized by Weertman (1973). Although equations 2.1 and 2.2 are identical, the parameters σ and ε in equation 2.1 are defined as the applied stress and steady state creep rate whereas in equation 2.2 they are defined as peak strength and applied strain rate. The constant c' in equation 2.2 is equal to inverse of c in equation 2.1.

Andrade (1910) put forward an empirical relationship between creep strain and time based on the viscous flow of metal. This is expressed in the form :

$$\varepsilon = \varepsilon_{o}+\beta t^{1/3}+Kt \qquad (2.3)$$

$$\beta t^{1/3} \ll 1$$

where t = time after load application

ε = sample strain at time t

β = fitting constants

K = steady state creep rate

ε_o = instanteneous strain

Andrade's equation was verified by Glen (1955) and Barnes et al. (1971) for ice and Ting and Martin (1979) for frozen soil who found that it could predict the primary creep reasonably better than the secondary and tertiary creep. The components of Andrade's equation are shown graphically in Figure 2.10.

Assur (1979) proposed an empirical model, as described by equation (2.4), which can describe the entire creep curve including primary, secondary and tertiary stages.

$$\dot{\varepsilon} = A \exp(\beta t)\ t^{-m} \qquad (2.4)$$

where ε is the strain rate, t is the time, A, β and m are constants. Although this model describes the entire creep curve, it does not take into account the effect of temperature and stress level. It is obvious from the literature that a general model, which takes into account all the variables affecting the strength and deformation properties, is yet to be developed.

2.2 MECHANICS OF FROZEN SOIL

2.2.1 Structure of Frozen Soil

The basic constituents of frozen soils are solid mineral

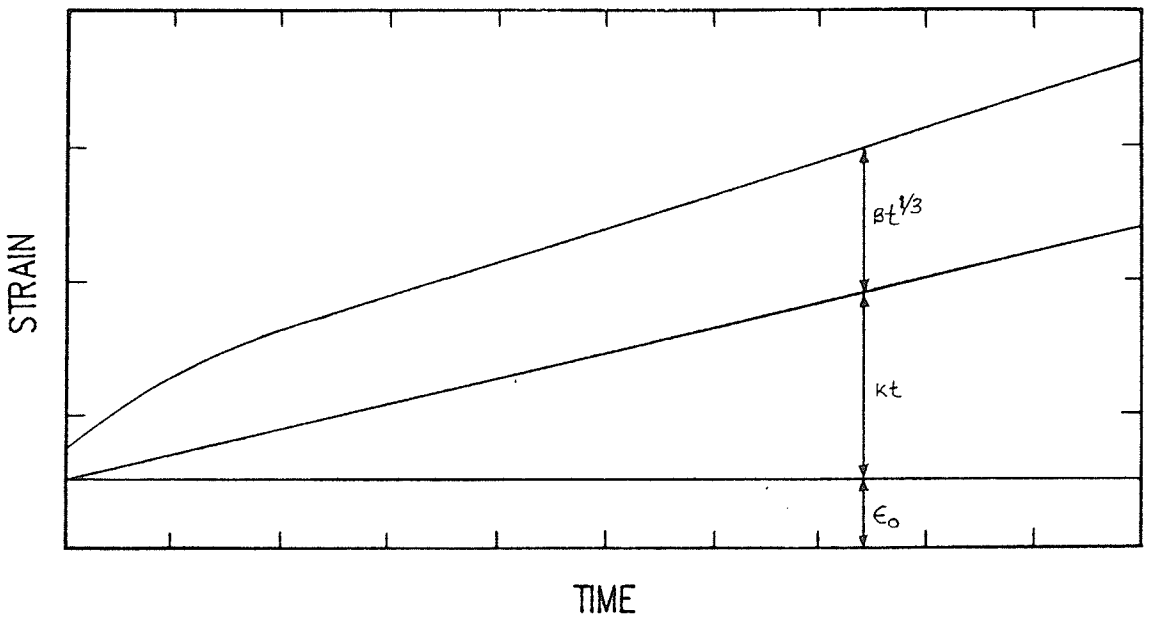


Figure 2.10 Components of the Andrade equation

particles, viscoplastic ice inclusions, unfrozen water and gaseous inclusions. All of these constituents are related to one another in ways that depend on the properties of the individual phases and on the levels of external disturbances.

The solid mineral particles of frozen soils exert an essential influence on the properties of the frozen soil, which depend not only on the sizes and shapes of the particles, but also on the physicochemical nature of their surfaces. The nature of the surfaces is generally determined by the mineralogical composition of the particles and the composition of cations that they have absorbed. The shapes of the mineral particles also have a large influence on the load transfer mechanism within the frozen soil system. If the particles are flat the external forces remain untransformed, while they may reach enormous values in the case of sharp-angular mineral particles. Tsytovich (1975) found that an external pressure of 0.2 MPa could cause an internal stress of 117 MPa due to particle shape and orientation. Such a high pressure can occur only within the elastic range of deformation and eventually decrease with time because of the increase in contact area.

The size of the mineral particles also has an appreciable influence on the behaviour of frozen soils. The specific surface area increases with a decrease in grain size of the mineral. The unfrozen water, which influences the mechanical behaviour, increases with an increase in specific surface area and consequently with decrease in grain size. Mineralogical composition also affects the behaviour depending on the interaction of the mineral particle with the pore ice.

Tensile and shear adhesion tests by Jellinek (1962,1967) on ice which had been frozen to various surfaces with varying roughness, showed that cohesive type breaks, within the ice crystals, were observed in tension tests, independent of surface roughness. Adhesive type breaks at the interface between the ice and the solid were observed in shear tests, with strength as a function of surface roughness, temperature and rate of shear strain. The strength of adhesion increased with an increase in surface roughness and a decrease in temperature, but below -13°C the adhesive strength was independent temperature and surface roughness.

Ice is responsible in large measure for the mechanical properties of frozen soil. With variations in thermodynamic conditions such as temperature and pressure, the properties of ice such as structure, viscosity etc. may undergo considerable variations. These changes result in instability of the properties of both the ice and the frozen soil. The pore ice is polycrystalline with a random crystal orientation. Under ordinary condition its response to deviatoric stress is governed by the motion of dislocations and/or microfracture.

It is generally agreed that a film of unfrozen, liquid-like water exists around soil particles in the frozen soil. According to Tsytovich (1975) this liquid-like layer consists of strongly bound water and loosely bound water. Because of the very large electro-molecular forces of the surface, the strongly bound water in the vicinity of the solid particle cannot form hexagonal crystal lattices even at very low temperatures. The loosely bound water

freezes at temperatures below 0°C. The thinner the layers of loosely bound water, the stronger will be the effect of soil mineral particle surfaces on the freezing process and the lower will be the freezing temperature. The amount of unfrozen water present in the frozen soil at a certain temperature can be related to the specific surface area of the mineral particle (Anderson and Tice, 1972). A recent investigation showed that in a frozen clay, unfrozen film may exist down to a temperature of -110°C (Ladanyi, 1985). From the above discussion one can conclude that with an increase in specific surface area, the unfrozen water content increases at a constant temperature. Consequently with an increase in surface area as the particle size gets smaller, the thickness of bound water decreases requiring more energy to freeze the water.

The gaseous components of frozen soil are water vapour and gases. Their role in the frozen soil is to produce porosity which affects the compressibility characteristics of frozen soil.

Ting et al. (1983) proposed a conceptual frozen sand structure (Figure 2.11), based on an extensive literature review, having the following characteristics :

- in coarse grained frozen soils, solid contacts exists between most particles
- continuous unfrozen water exists at the ice-to-soil solids interface and at grain boundaries in the ice phase
-ice in frozen soil is polycrystalline in nature and the

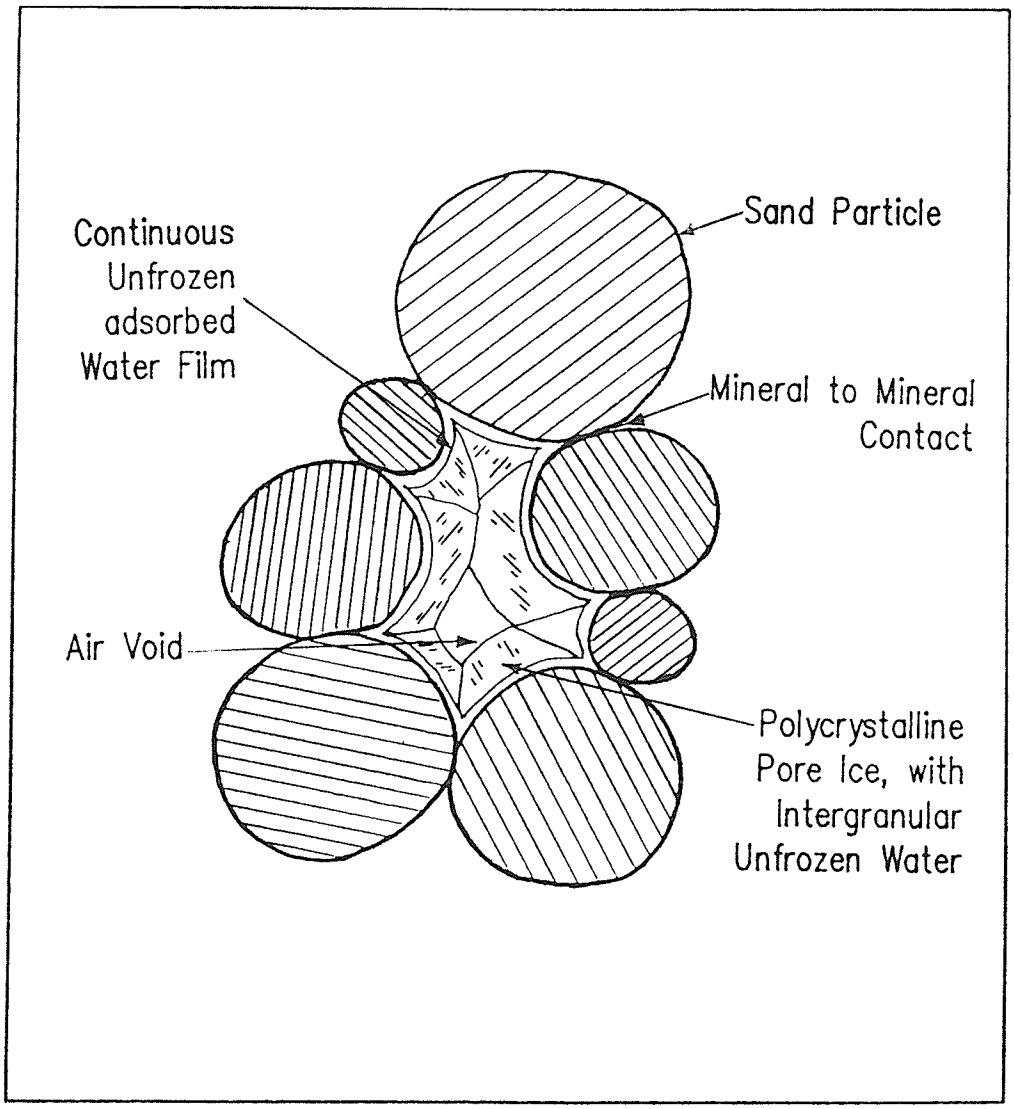


Figure 2.11 Two dimensional schematic of the proposed structure of the frozen sand system (after Ting, 1981)

number of ice grains in a pore is equal to the number of particles adjacent to the pore.

The freezing process has an appreciable influence on the structure of pore ice and thereby on the frozen soil. It is generally agreed that a layer of unfrozen water exists around the soil particles in frozen soil. This layer is mobile, continuous and capable of mass transport. It is understood that ice nucleates in the presence of silicate particles adjacent to the unfrozen adsorbed water film rather than directly on the particle surface. Corte (1962) observed in the case of soil freezing upward, the freezing front could carry soil particle floating on the heaving ice surface. This is possible if an unfrozen water film surrounds the soil particles.

The freezing curve of water saturated Lyubertsy quartz sand is shown in Figure 2.12 (Vyalov, 1975). The first segment, I, corresponds to initial supercooling of the sample without formation of any ice. The supercooling temperature depends on the material type. For this sand it was about -3°C. As soon as the pore water begins to freeze, a significant amount of latent heat of ice formation is released and the temperature of the soil rises to very close to 0°C as shown by stage II. At this temperature all the free water present in the sand freezes, the time of freezing depends on moisture content, freezing rate and the dimension of the sample. This is shown by the part III of the curve. When all the free water in the sample turns into ice, cooling of the sample starts as shown by the part IV. If the temperature is raised as shown by the segment V, the temperature varies

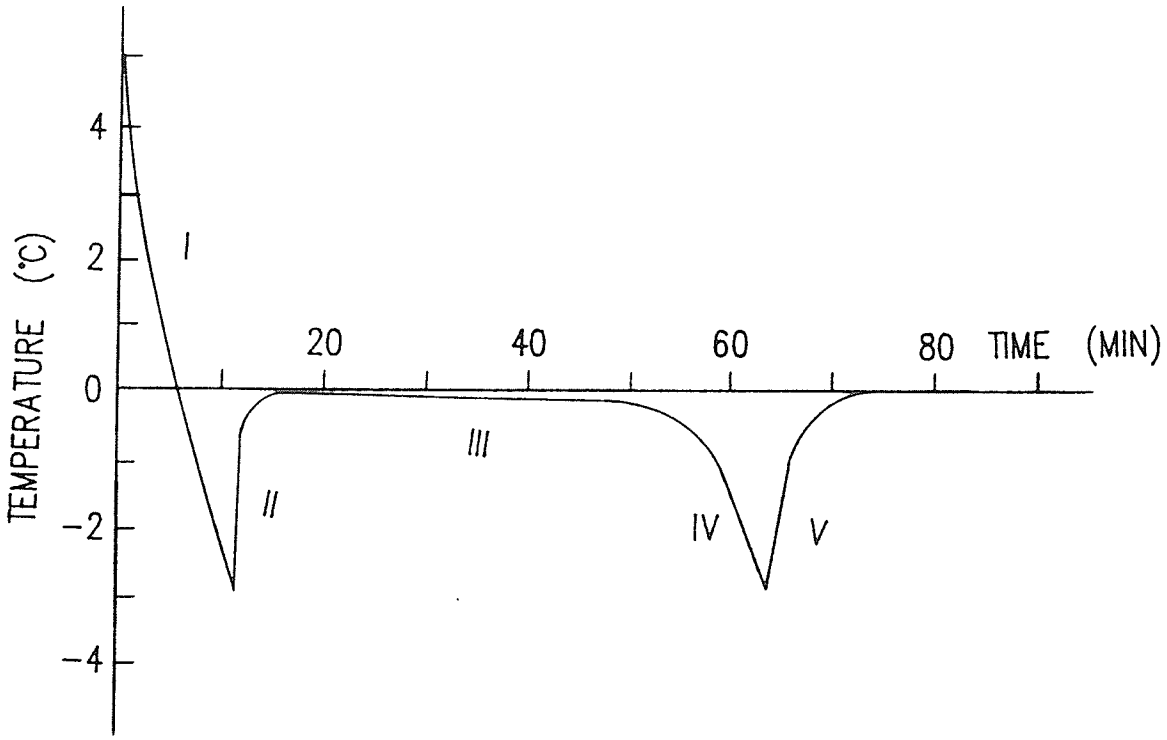


Figure 2.12 Cooling and freezing curve of sand with moisture content of 19.6 percent , refrigirant at −10°C (after Vyalov, 1975)

linearly at first, but then in curvilinear fashion. For sands the curvature starts approximately at temperatures ranging between -0.5 and -1°C. This shows that the absorption of the latent heat of ice formation begins even before the thawing temperature of the soil has been reached.

The rate of freezing plays an important role in determining the structure of ice and frozen soil, and consequently the mechanical behaviour. It is observed that the first freezing causes the air voids to become entrapped whereas slow unidirectional freezing drives the air void ahead of the freezing front.

2.2.2 Deformational Mechanisms of Frozen Soil

The rheological characteristics of frozen soil are a direct result of the presence of ice as a matrix which undergoes plastic flow under a load practically of any magnitude, causing reorientation of crystals. The presence of a viscous film of unfrozen water initiates and furthers the rhoelogical process when any additional load is applied.

The strong development of rheological processes in frozen soils is due to the peculiarity of their internal bonds. There are three basic types of internal bonds identified in frozen soils : i) purely molecular bond ii) ice cement bond and iii) structural bond. Purely molecular bond depends on the area of direct contact, distance between

mineral particles, their compactness and the physicochemical nature of the particles. Ice cement bond, which is responsible for the strength and deformation properties of frozen soil, depends on the temperature, ice content, structure of the ice and their position with respect to the applied force, unfrozen water, gas inclusions and cavities in the ice. Structural bonds depend on the conditions of formation and the subsequent existence of the frozen soil. The greater the inhomogeneity of frozen soil, the greater will be the number of structural and constitutional defects in it.

The strength and deformation properties of frozen soil differ from those of other solids in that the application of external load to a frozen soil always gives rise to irreversible restructuring, which causes stress relaxation and creep deformation under a very small load. Much of these behaviours can be attributed to the presence of pore ice. Three basic mechanisms of deformation of pore ice are identified : i)flow of ice in slow shear parallel to the basal plane of the crystals without any change in the structure of the ice, ii) microcracking, recrystallization, intergranular shifting and breakup into fragments with randomized orientation, iii) melting of ice under very high shear stresses due to the heat of friction along cleavage planes. Based on the discussion in the previous sections on the behaviour of frozen soils and ice, some qualitative and quantitative models for the observed behaviour are presented.

2.2.3 Strength of Frozen Soil

2.2.3.1 Effect of Mineral Particle Concentration

The ratio of mineral particles to ice affects the behaviour of frozen soils. Ice with some impurities has lower strength than pure ice. This is supported by the work of Goughnour and Andersland (1968) and Hooke et al. (1972). They observed that polycrystalline ice with sand particles of 1 to 3 percent by volume had about 10 percent lower peak strength than pure ice. This is attributed to the fact that the sand particles decrease the ice crystal size which is more prone to grain boundary slipping and even act as a site for primary dislocation. The peak strength starts increasing with the increase in sand ice ratio (Hooke et al., 1972). Goughnour and Andersland (1968) reported that the influence of interparticle friction and dilatancy became apparent when the sand concentration was increased beyond 42 percent. Kaplar (1971) showed that the peak strength started increasing rapidly when the sand concentration was increased beyond 40 percent. The strength increase occured as the sand remain ice saturated (Kaplar, 1973, Baker, 1979). Sayles and Carbee (1980) had shown that at silt concentration of less than 50 percent the strength was governed by ice matrix at low strains while at higher particle concentrations the stress-strain curve showed an increasingly strain hardening character.

2.2.3.2 Effect of Confining pressure

The strength of frozen sand consists of cohesion of the ice matrix and the frictional resistance of the sand grains. It has been found, however, that these sources of strength may be independent of

each other depending on the strain rate. For Ottawa sand if the strain rate is greater than 0.02/min, the ice matrix attains peak strength first at a strain less than 1.0 percent and then the soil skeleton resistance becomes a function of confining pressure and attains a peak strength at a strain of 10 percent (Sayles, 1973). This is shown in Figure 2.13a. The first yield point is considered to be the yielding of ice matrix while the second one corresponds to the sand-ice composite. Failure envelope based on the two peaks are presented in Figure 2.13b. Chamberlain et al. (1972) observed that at low confining pressure the shear strength increased for Ottawa sand but decreased for silt. He suggested that the strengthening of the Ottawa sand was due to particle interlocking and interparticle friction and while the low strngth for silt was due to the presence of unfrozen water film. In the intermediate pressure range, both the Ottawa sand and the silt exhibited decreasing shear strength with increasing confining pressure. This was due to the onset of pressure melting caused by stress concentration and the suppression of dilation due to high pressure. In the high pressure region, about 100 MPa, both the Ottawa sand and the silt showed an increase in shear strength due to increase in confining pressure. In this pressure range ice/water phase transformation occurred and began to start behaving as unfrozen soil. This can be represented by a schematic diagram shown in Figure 14. Very similar results of a study of the effects of high confining pressures on the strength of frozen Ottawa sand were obtained by Simonsen (1974) and Sego (1984). Parameswaran and Jones (1981) found that yield and peak strength increased with increasing confining pressure up to 35 to 40 MPa, beyond which pressure melting causes decrease in strength.

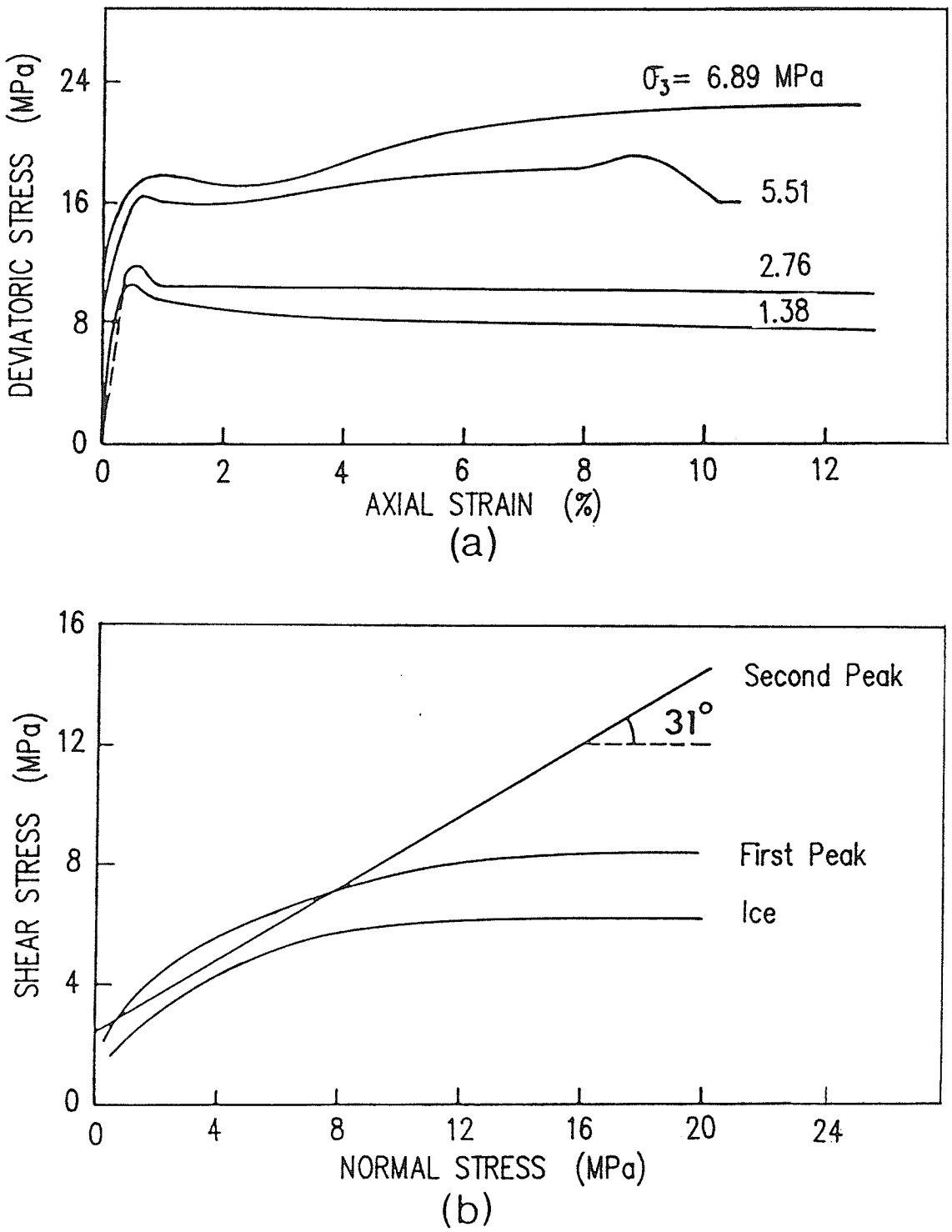


Figure 2.13 Results of axial compression tests with frozen Ottawa sand
(a) Stress–strain curve at different confining pressure
(b) Mohr's envelopes
(after Sayles, 1973)

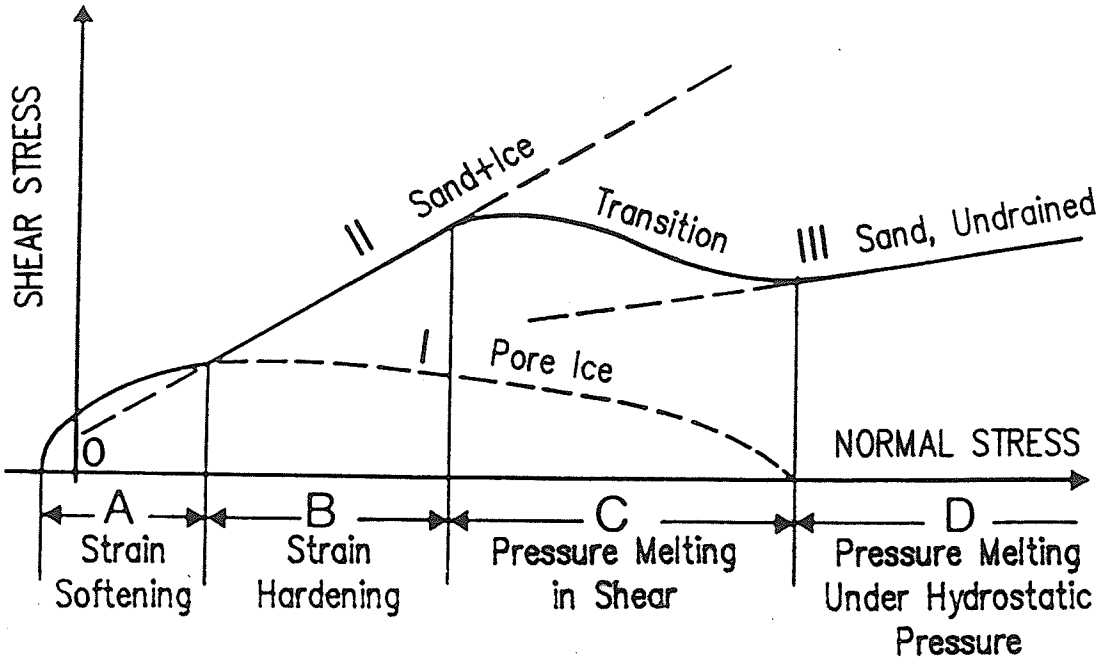


Figure 2.14 Schematic representation of the whole failure envelope for frozen Ottawa sand (after Chamberlain et al., 1972, and Sayles, 1973)

2.2.3.3 Effect of Temperature

Temperature has a marked influence on the behaviour of frozen soil. Any change in temperature alters the constitution of the frozen soil by changing the amount of unfrozen water content and influencing the strength of intergranular ice. Haynes and Karalius (1977) (Figure 2.15) observed that the uniaxial compressive strength increased with the lowering of temperature. The strength increase was dependent on the strain rate having higher strength with higher strain rate. The strain rate and temperature had very little effect on the tensile strength at temperatures lower than about -5°C whereas the tensile strength increase was noticed between 0°C and -5°C. Triaxial tests performed by Smith and Cheatham (1975) showed that with the increase in confining stress, the temperature dependence of strength decreased.

Andersland and AlNouri (1970) and Andersland and Douglas (1970) had tried to express the strength variation of frozen soils with temperature by means of Rate Process Theory and found the theory to be useful only if very high values of apparent activation energy are substituted into the equation.

Vyalov et al. (1962), Parameswaren (1980) and Bragg and Andersland (1980) have used power law to express variations of strength with temperature. A procedure for determining the parameters for the power law was given by Ladanyi (1972).

2.2.3.4 Effect of Strain Rate

Parameswaran (1980), Bragg and Andersland (1980) studied the

effect of strain rate on the uniaxial compressive strength of frozen sand. Figure 2.16 shows the stress-strain curve for a frozen sand at different strain rates at -10°C. This shows that the peak strength increased with an increase in strain rate. Figure 2.17 plots the compressive strength against strain rates. The compressive strength increased with an increase in strain rate upto 10^{-5}/sec. The strain rate higher than 10^{-5}/sec had no effect on the compressive strength. Triaxial tests on the Ottawa sand by Sayles (1973) showed (Figure 2.18) that strain dependence of strength did not change appreciably as the confining pressure was increased.

2.2.4 Deformation of Frozen Soil

Deformation behaviour of frozen soil depends on the pore ice which normally binds the grains together and fills most of the void spaces. Frozen soil, like ice, undergoes time-dependent deformation or creep under constant stress. Experimental evidence from literature shows that upon application of a deviatoric stress, the frozen soil shows an elastic deformation followed by a stage of decelerating creep which gradually stabilizes and eventually starts accelerating depending on the stress level. Similar to that of ice, the entire creep process of the frozen soil can be described as primary creep or decelerating creep, secondary or steady state creep and tertiary or accelerating creep.

An external load causes stress concentration at the point of

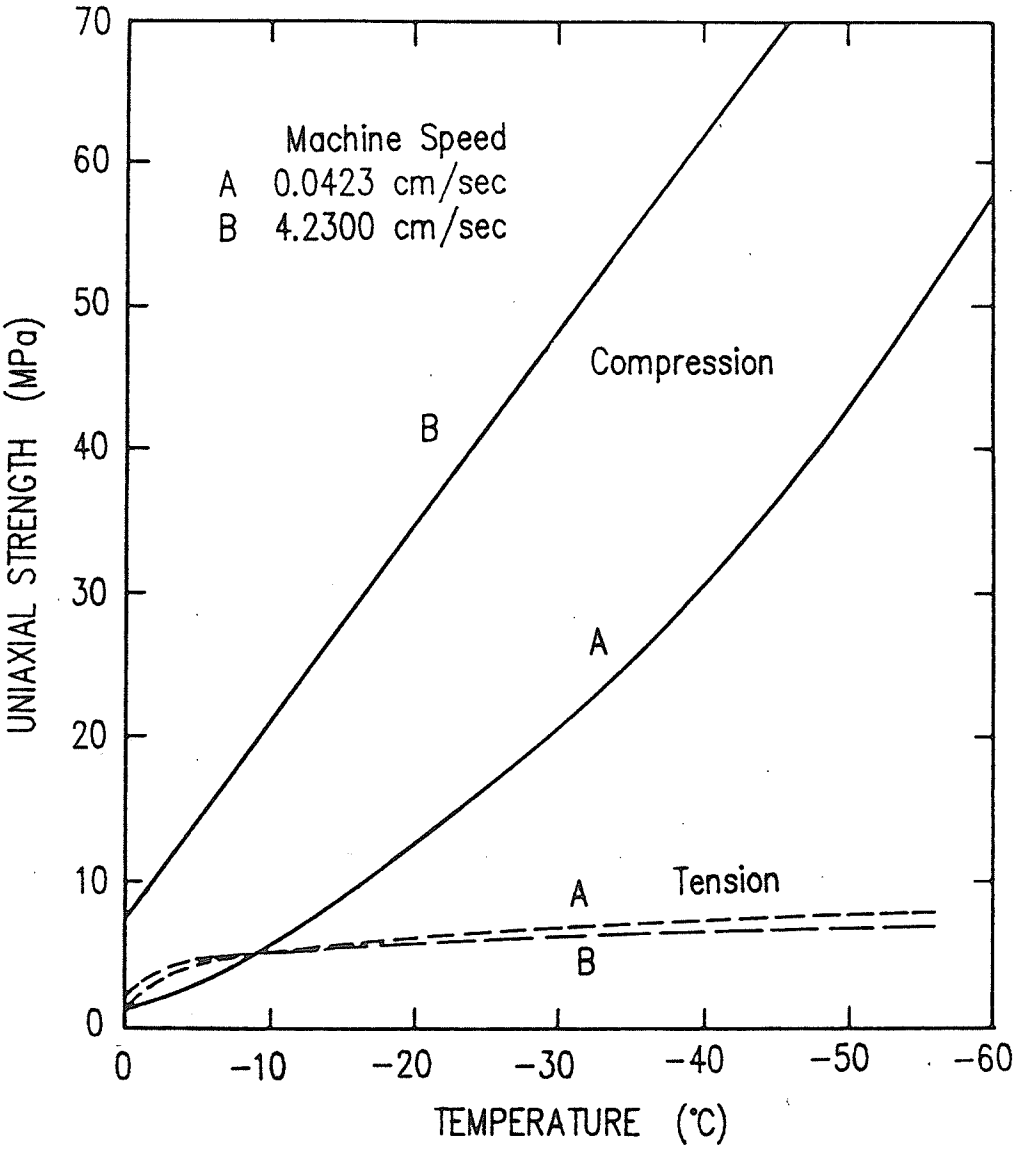


Figure 2.15 Average strength versus temperature for a frozen silt in uniaxial compression and tension tests (after Haynes and Karalius, 1977)

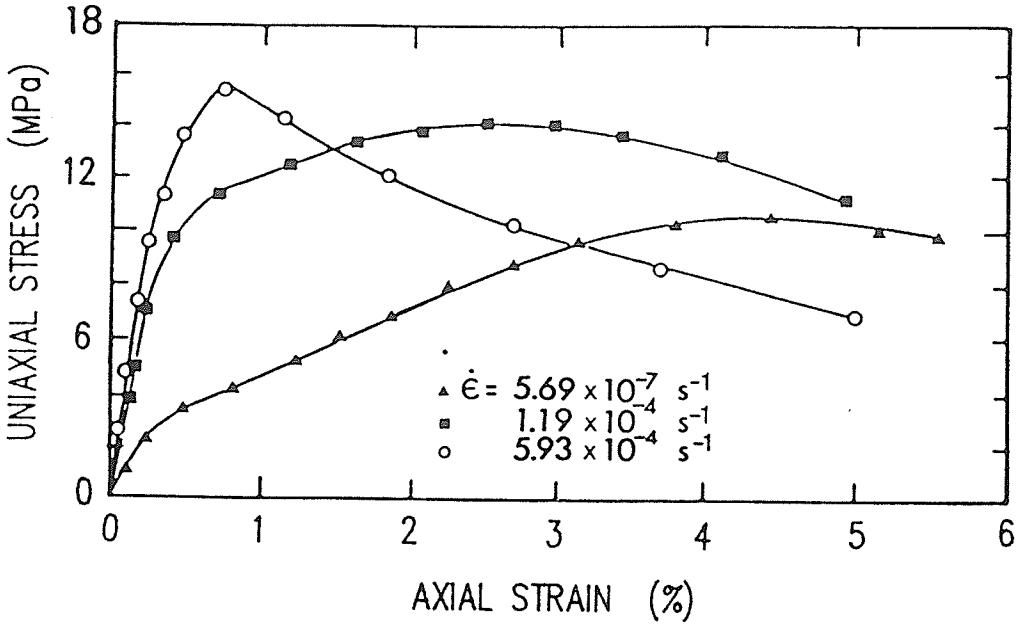


Figure 2.16 Typical stress–strain curve for frozen sand at different strain rates and tested at −10°C (after Bragg and Andersland, 1980)

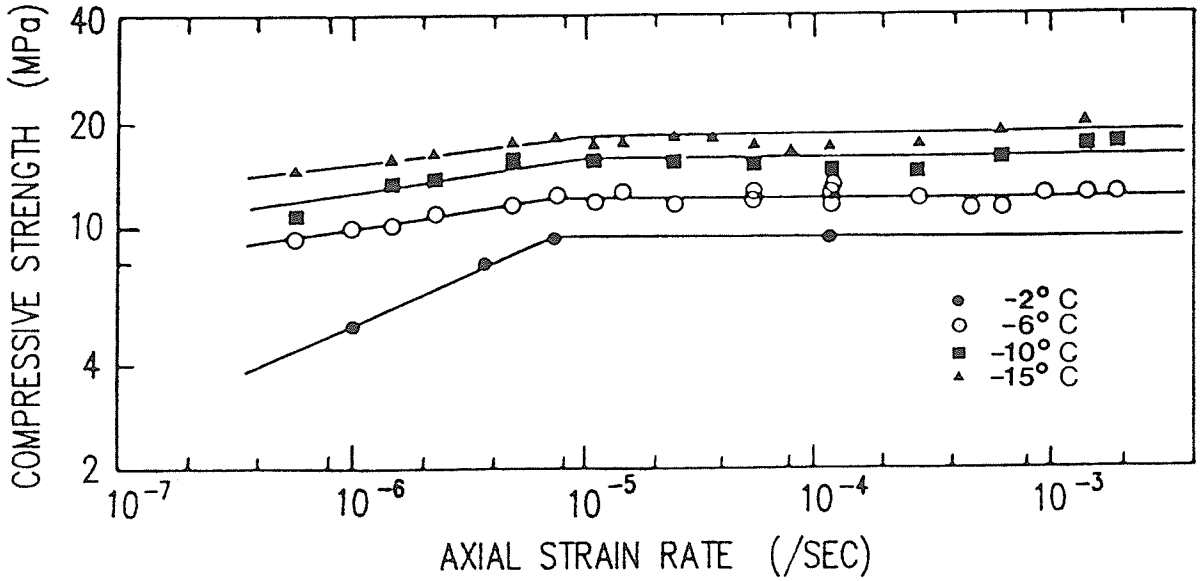


Figure 2.17 Compressive strength versus strain rate for a frozen sand at different temperature (after Bragg and Andersland, 1980)

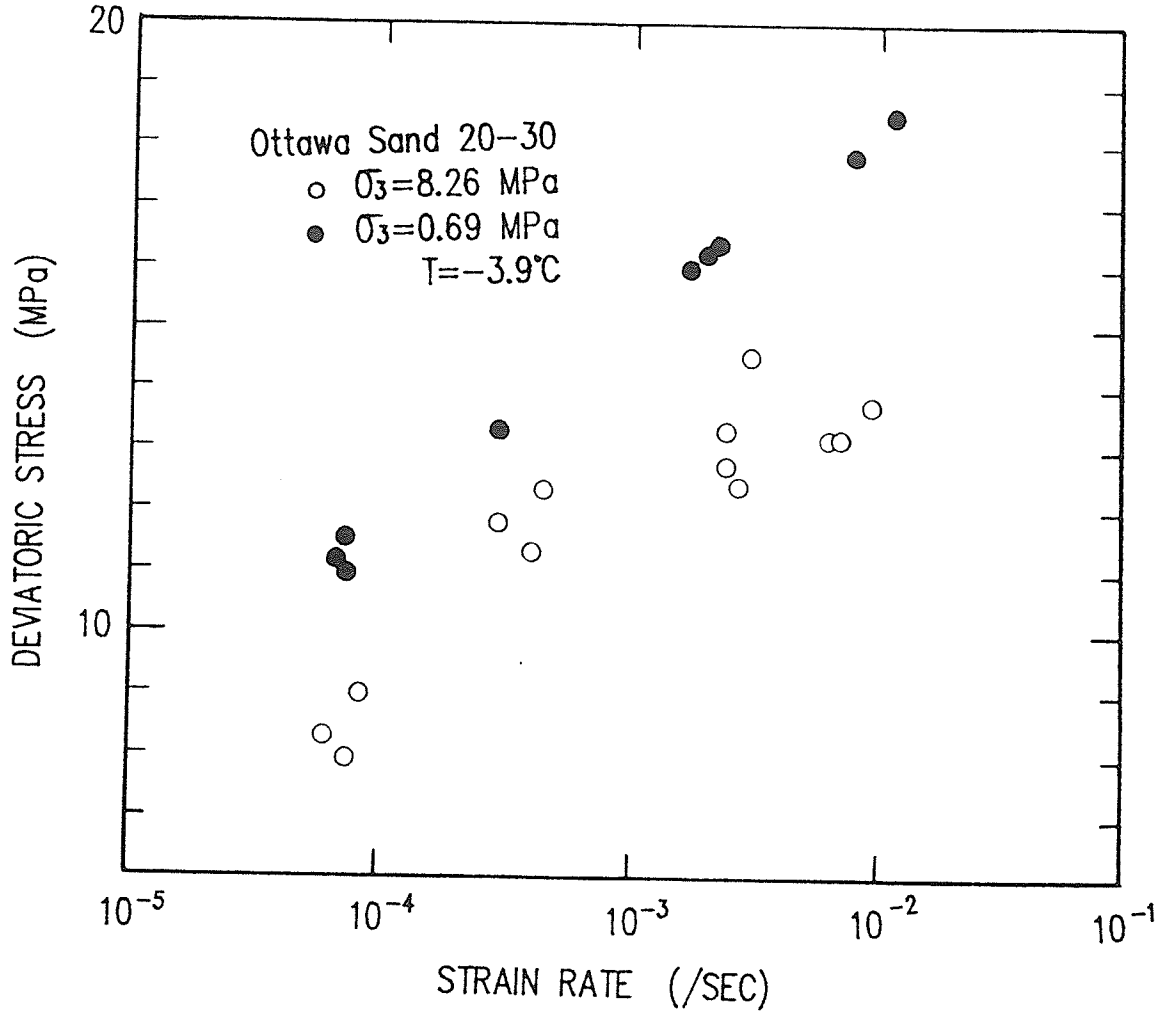


Figure 2.18 Effect of strain rate on the triaxial strength of frozen soils (after Sayles, 1973)

contact of the grains and develops stresses many times higher than the average stress calculated on the basis of the applied load. This causes plastic flow and melting of ice, and dynamic equilibrium is disturbed. The pore water caused by the melting of ice moves to lower stress points and refreezes. At the same time, ice cementation bond in the weaker spots yields and reorientation of the ice crystals and mineral particles takes place which tend to orient their basal planes parallel to the slide direction. This process, accompanied by reduction of shearing strength, denser packing of the mineral particles, increase in intermolecular bonds, build up of new ice cementation bonds, causes both strengthening and weakening. If the strengthening exceeds weakening, the deformation process is damped, but if weakening overcomes strengthening, prolonged and accelerating creep occurs.

2.2.4.1 Effect of stress Level

Depending upon the stress level the deformation of frozen soil includes instantaneous axial deformation followed by regions of primary, secondary and tertiary creep. Vyalov (1962) stated that at low stresses strengthening of frozen soil led to damped creep deformations whereas at higher stresses structural weakening led to increasing creep rate and subsequent failure. Plot of axial stress versus the reciprocal of temperature (Andersland and Akili, 1967, Figure 2.19) provided a graphical means for predicting creep rates for selected stresses and temperatures. Damped creep occurs below the region which has a creep rate of 10^{-7}/sec. Strain rate versus time

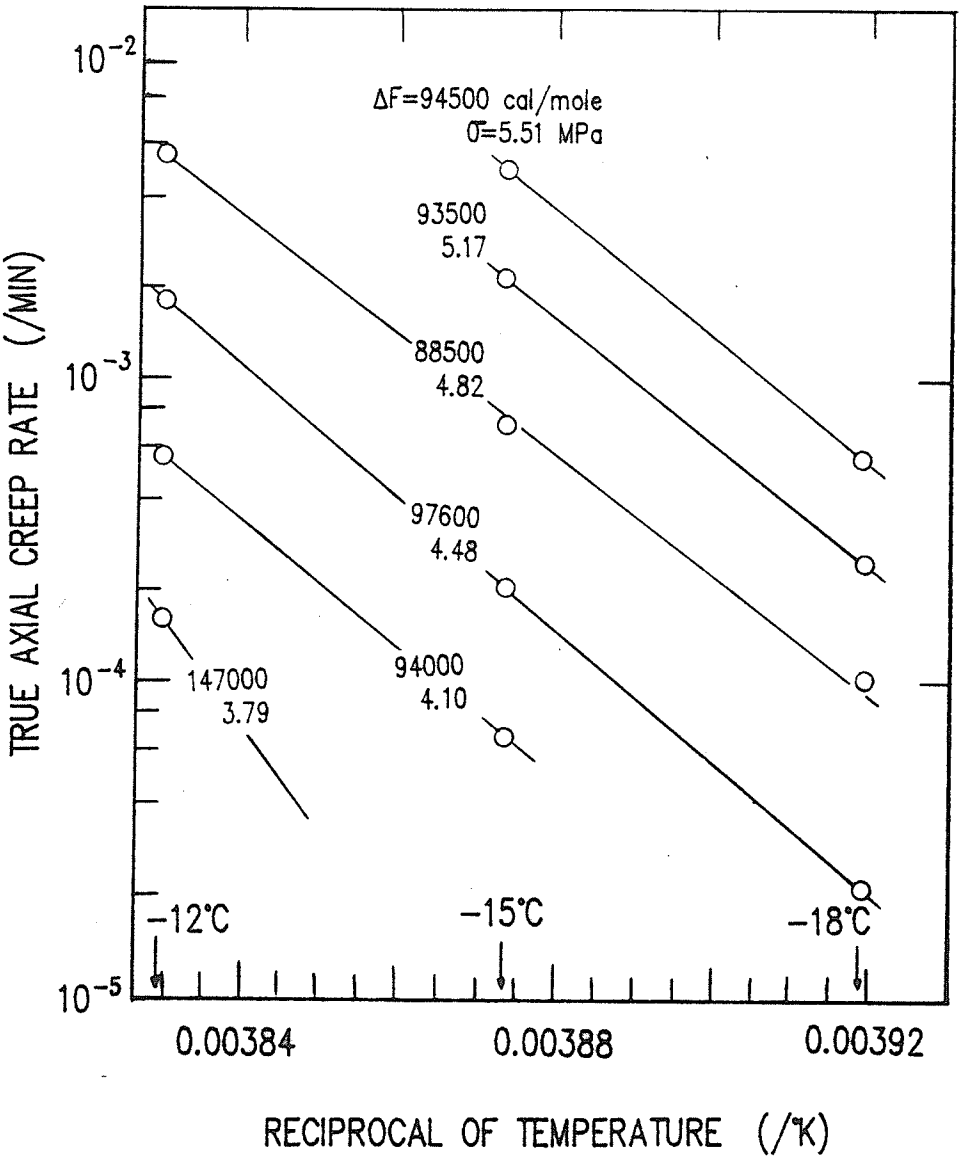


Figure 2.19 True axial creep rate as a function of reciprocal of temperature (after Andersland and Akili, 1967)

for various stress level are plotted in Figure 2.20 using data obtained by Rein et al. (1975) from unconfined compression tests on Ottawa sand at -8.5°C. This shows that at each stress level the strain rate reached a minimum value before further acceleration. Assur (1980), Mellor and Cole (1982) and Martin et al. (1981) reported that creep failure occurred when creep rate reached its minimum creep rate. It is observed from the above plot that the time to minimum creep rate increases with the decrease in stress level. Based on Vyalov's power law equation Ting (1983) expressed the minimum creep rate as:

$$\dot{\varepsilon}_m = \dot{\varepsilon}_c \left(\frac{\sigma_1}{\sigma_c}\right)^n \qquad (2.5)$$

in which $\dot{\varepsilon}_m$ = minimum creep rate

$\dot{\varepsilon}_c$ = arbitrary normalizing strain rate at stress level, σ_c

σ_1 = applied stress

n = material property

Rein et al. (1975) suggested that possibly for every material there was a stress level below which damped creep behaviour might be present. This stress level might possibly be defined as the limiting long term strength of the material.

2.2.4.2 Effect of Temperature

The creep behaviour of frozen soil is extremely sensitive to temperature. The ice and unfrozen water ratio in the frozen soil matrix is not a constant but changes with temperature and consequently

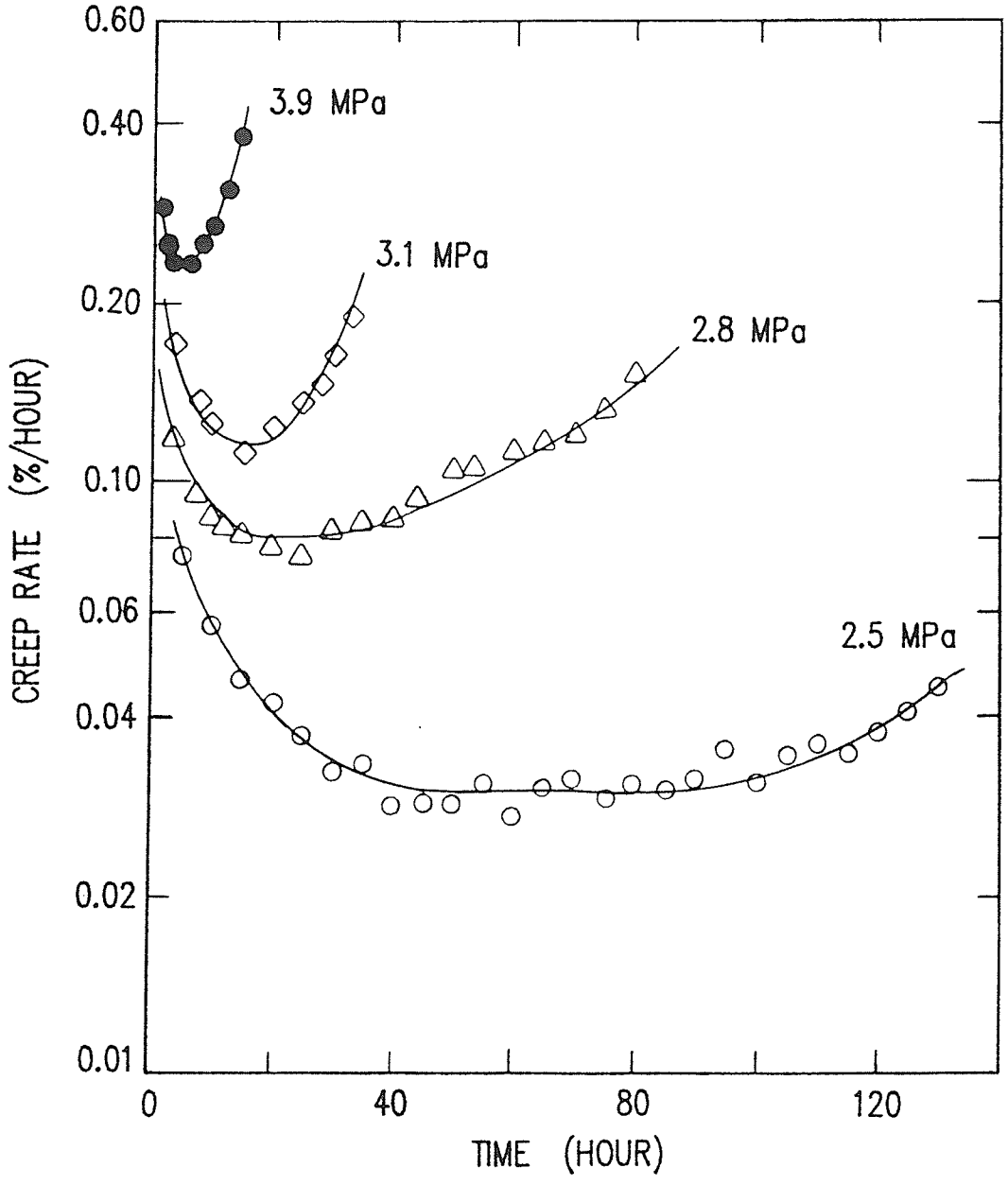


Figure 2.20 Creep rate as a function of time (after Rein et al., 1975)

changes the matrix of the frozen soil and thereby its behaviour. The plot of minimum strain rate in log scale against the reciprocal of applied stress at various temperature in Figure 2.21 (Yalin and Carbee, 1983) shows that as the temperature decreases the applied stress increases for the same minimum strain rate. From Figure 2.22, time to failure against reciprocal of stress, it is observed that time to failure increases with the decrease in temperature with the stress remaining constant. They have expressed the relationship as :

$$\dot{\varepsilon}_m = \dot{\varepsilon}_c \exp(-K \left(\frac{1}{\sigma} - \frac{1}{\sigma_c} \right)) \qquad (2.6)$$

$$\dot{\varepsilon}_m = c t_m^{-n} \qquad (2.7)$$

where $\dot{\varepsilon}_c$ = critical creep rate

σ_c = critical creep strength

$\dot{\varepsilon}_m$ = minimum creep rate

t_m = time to reach minimum creep strain

c, n = material constant

K = function of temperature = $125.7\ 0^{1.1}$ for silt

Martin et al. (1981) observed similar behaviour when testing Manchester fine sand under uniaxial compression. It is evident from all these that the frozen soil is far more temperature sensitive than ice. This extreme sensitivity to temperature results in experimental problems and comparison of results from various sources.

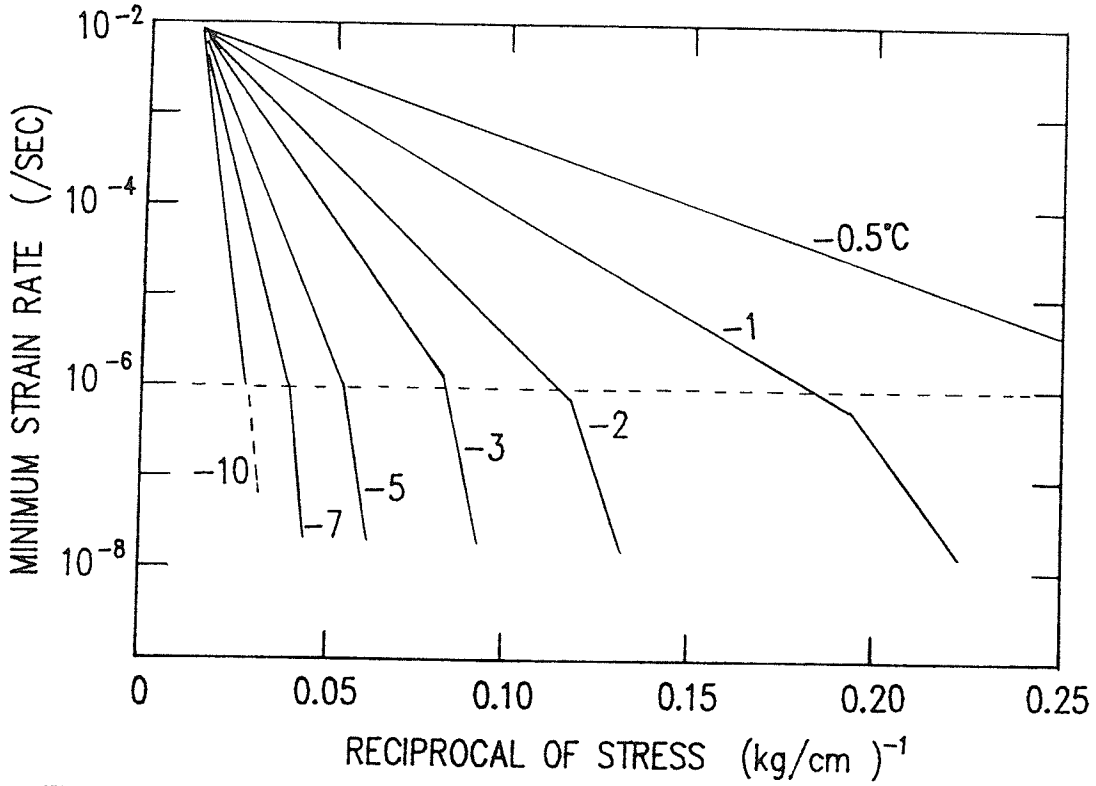


Figure 2.21 Log of minimum strain rate versus reciprocal of axial stress (after Yalin et al., 1983)

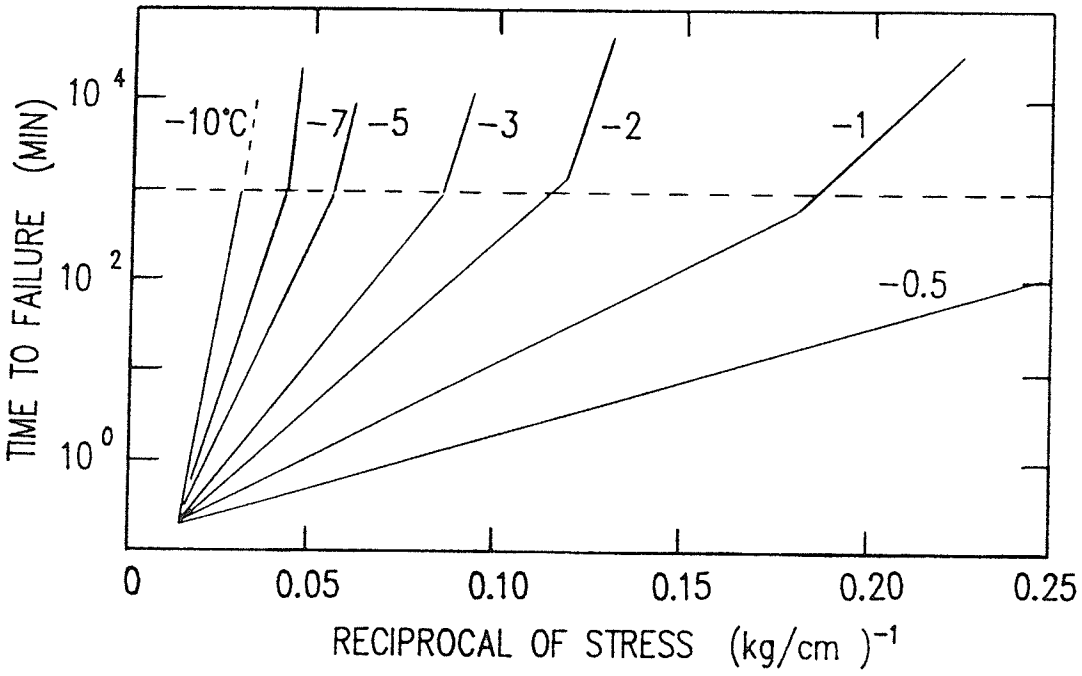


Figure 2.22 Log of time to failure versus reciprocal of axial stress (after Yalin et al., 1983)

2.2.4.3 Effect of Confining Stress

Consistent with other structured materials, the strength of frozen soil increases with increase in confining pressure and thereby the creep rate under any deviatoric stress decreases. A set of creep curves for Ottawa sand at constant axial stress and different confining pressures are shown in Figure 2.23 (Sayles, 1973). It is evident from the curves that for the same deviatoric stress of 4.13MPa damped creep occurs at the confining pressure of 5.5 MPa whereas accelerated creep occurs at the confining pressure of 1.38 MPa.

Alkire and Andersland (1973) and Andersland and AlNouri (1970) studied the effect of confining pressure on the creep behaviour of Ottawa sand. They related the strain rate with the deviatoric stress and the octahedral stress by the following equation.

$$\dot{\varepsilon} = c \exp(n(\sigma-\sigma_3)) \exp(-(m\sigma_{oct})) \qquad (2.8)$$

where $\sigma_{oct} = (1/3)(\sigma_1+\sigma_2+\sigma_3)$ and c, m and n are constants.

2.2.5 Quantitative Models of Strength and Deformation of Frozen Sand

All existing creep theories of frozen soils had their roots in theories originally developed for metals of which strains are usually taken to be small and upon which a superimposed hydrostatic stress hardly has any effect.

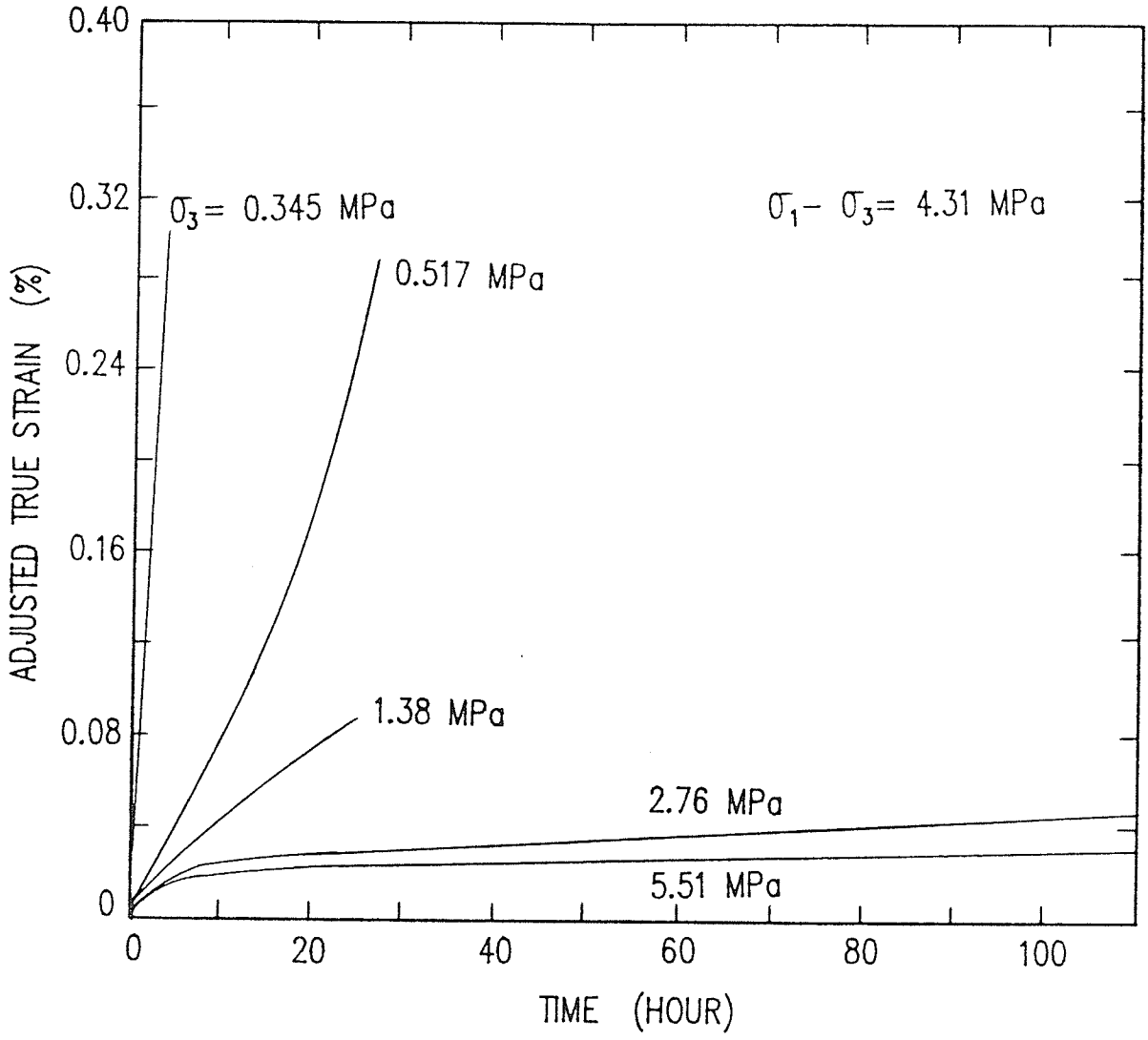


Figure 2.23 Creep curves for frozen Ottawa sand at constant axial stress and different confining pressure (after Sayles, 1973)

Andrade (1910) demonstrated that the tensile creep, of several pure metals and a selection of alloys, under constant load could best be represented by :

$$L = L_o(1+\beta t^{1/3}) \exp(kt) \tag{2.9}$$

where L is the length of the specimen at time t under a constant stress and L_o is the initial length immediately before loading. Andrade found that the constant k and β increased in roughly analogous fashion with stress and temperature.

Bailey (1929) and Norton (1929) expressed the creep law in the form of simple power law :

$$\dot{\varepsilon} = \frac{1}{\gamma}\left(\frac{\sigma}{\sigma_n(T)}\right)^{n(T)} \tag{2.10}$$

where $\dot{\varepsilon}$ = creep rate

$\sigma_n(T)$ = a suitable function of temperature

γ = a fixed standard time unit introduced to give the creep stress σ_n the dimension of stress

n = a creep exponent ($n \geq 1$)

Odqvist and Hult (1962), based on the power law, generalized the creep equation, for uniaxial and multiaxial states of stress, of nondamped creep behaviour of metals. They expressed the steady state creep rate in terms of equivalent strain rate and stress assuming the validity of Von Mises plasticity rule and the volume constancy for all

plastic deformation including creep deformation.

$$\dot{\varepsilon}_e = \varepsilon_c \left(\frac{\sigma_e}{\sigma_c}\right)^n \qquad (2.11)$$

where $\dot{\varepsilon}_e$ = equivalent strain rate

σ_e = equivalent stress

ε_c&σ_c = temperature dependent creep parameter

n = creep exponent

For axially symmetric state the equivalent stress is replaced by $(\sigma_1-\sigma_3)$.

Vyalov (1962) proposed a primary creep model representing the total strain as the sum of the initial strain, ε_o, and the time dependent strain, $\varepsilon(t)$.

$$\varepsilon = \varepsilon_o+\varepsilon(t) \qquad (2.12)$$

For negligible initial strain, ε_o, the total strain may be approximated to :

$$\varepsilon = \varepsilon(t) = \left(\frac{\sigma t^{\lambda}}{w(\theta+\theta_o)^k}\right)^{1/m} \qquad (2.13)$$

where θ = negetive temperature (^oC)

θ_o= reference temperature usually -1^oC

w,k,λ,m = soil parameters

The strain rate may be written by differentiating the equation (2.13) with respect to time :

$$\dot{\varepsilon} = \frac{\lambda}{m}\left(\frac{\sigma}{w(\theta+\theta_\infty)^k}\right)^{1/m} t^{(\lambda-m)/m} \qquad (2.14)$$

The equation (2.14) confirms that the strain rate decreases with time and hence the equation (2.13) is indeed a primary creep model.

Vyalov (1978) proposed another equation for frozen soil in the prefailure state where he has taken into account of the effect of mean normal stress.

$$\dot{\varepsilon}_\infty = \left(\frac{c_\infty}{B}\right)^{1/m} \left(\frac{\sigma_\infty t^\alpha}{C_\infty+\sigma_m+\tan\phi_\infty}\right) \qquad (2.15)$$

where c_∞ = temperature dependent adhesion at $t=\infty$

Φ = internal friction angle at $t=\infty$

m = creep exponent

$B = w(1+\theta)^k$ = temperature dependent experimental parameter

α = material characteristic

Odqvist (1966) proposed a creep model as given by equation (2.16) for multiaxial states of stress based on the total deformation theory which is particularly suitable to describe behaviour of material in the secondary stage of creep, taking account of primary creep with

its total amount as correction.

$$\frac{d\varepsilon_{ij}}{dt} = \frac{3}{2}\left(\frac{d}{dt}\left(\left(\frac{\sigma_e}{\sigma_o}\right)^{n-1}\frac{S_{ij}}{\sigma_o}\right) + \left(\frac{\sigma_e}{\sigma_c}\right)^{n-1}\frac{S_{ij}}{\sigma_c}\right) \qquad (2.16)$$

where σ_e = equivalent stress

σ_c = proof stress

S_{ij}=stress deviator tensor

σ_o, n_o, n =material constant

$\frac{d\varepsilon_{ij}}{dt}$ = creep rate tensor

The above equation (2.16) is founded on the following hypotheses :

i) material is incompressible

ii) creep rate is independent of superimposed hydrostatic pressure

iii) existence of a flow potential

iv) material is isotropic

v) Norton's law holds in the special case of uniaxial stress

Ladanyi (1972) proposed a secondary creep model adapted from the theory of Odqvist (1966) and Hult (1962). At constant temperature and stress Ladanyi expressed strain as :

$$\varepsilon = \varepsilon_{ie}+\varepsilon_{ip}+\varepsilon_c \qquad (2.17)$$

where ε_{ie} = pseudo-instantaneous elastic strain

ε_{ip} = pseudo-instantaneous plastic strain

ε_c = creep strain

The pseudo-instantaneous elastic and plastic strains are the functions of stress and temperature. The creep strain rate may be described by :

$$\frac{d\varepsilon_c}{dt} = G(\sigma,T) = \varepsilon_c \left(\frac{\sigma}{\sigma_c(T)}\right)^{n(T)} \tag{2.18}$$

where ε_c = arbitrary strain rate corresponding $\sigma_c(T)$ (proof stress)

n = material constant

σ = applied stress

The equation (2.17) for a given material at a constant temperature is replaced by :

$$\varepsilon = \frac{\sigma}{E} + \varepsilon_k\left(\frac{\sigma}{\sigma_c}\right)^k + t\dot{\varepsilon}_c\left(\frac{\sigma}{\sigma_c}\right)^n \tag{2.19}$$

where the first term in the equation (2.19) represents pseudo-instantaneous elastic strain, the second term plastic strain and the third term creep strain. Experimental evidence in frozen soils shows that for a time interval greater than about 24 hours the two instantaneous strain terms together constitute less than 10 percent of the total creep strain (Vyalov, 1959).

For a period longer than about one day it may be sufficient for practical purposes to retain only the third term in the equation (2.19), i.e.

$$\varepsilon = t\dot{\varepsilon}_c \left(\frac{\sigma}{\sigma_c}\right)^n \tag{2.20}$$

Ladanyi expressed the equation (2.20) in terms of strain rate and mean normal stress in the case of multiaxial state of stress :

$$\varepsilon = \dot{\varepsilon}_c \left(\frac{(f+2)(\sigma_1-\sigma_3)-3(f-1)\sigma_m}{3\sigma_{cu}f(\theta)}\right)^n \tag{2.21}$$

where

$$f(\theta) = \left(1+\frac{\theta}{\theta_c}\right)^w$$

$$f = \frac{1+\sin\Phi}{1-\sin\Phi}$$

$$\sigma_m = \frac{1}{3}(\sigma_1+\sigma_2+\sigma_3)$$

$\dot{\varepsilon}_c$ = arbitrary strain rate

σ_{cu} = value of σ_c at ε_c in compression test

The equation (2.21) assumes full mobilization of internal friction over the whole region of pre-failure state which leads to a non-zero strain rate at zero stress difference. Therefore the application of the equation (2.21) should be limited either to strain close to failure or to those contained within a narrow range of mobilization of internal friction.

Odqvist (1966) and Hult (1962) in effect regarded a metal in

stationary creep as an incompressible generalized Newtonian fluid whose viscosity function obeys the power law; when solving boundary value problem they often added the assumption of small deformations so that the stretching tensor (rate of strain) could be replaced by time derivative of the infinitesimal strain tensor. Although Ladanyi made adhoc modifications to account for the effect of hydrostatic pressure, he implicitly adopted the assumption of small deformations when employed the infinitesimal strain tensor and its time derivative in all his formulations.

Andersland and AlNouri (1970) proposed a creep equation based on exponential form serving the same general purpose as equation (2.21) :

$$\dot{\varepsilon}_c = \frac{A \exp(N(\sigma_1-\sigma_3))}{F(T) \exp(m\sigma_m)} \qquad (2.22)$$

where $F(T) = \exp(L/T)$

$L = U/R$

U = activation energy

T = absolute temperature

R = universal gas constant

and A, N and m are experimental parameters.

Goughnour and Andesland (1968) proposed a constitutive equation to model the entire creep phenomenon including the accelerating or tertiary creep :

$$\dot{\varepsilon}_p = \frac{K_1}{\sqrt{t}} \exp(-n_1\sqrt{t}) + K_2 \exp(n_2 t) \qquad (2.23)$$

where all the four soil parameters n_1, n_2, K_1, and K_2 are functions of both stress and temperature and $\dot{\varepsilon}_p$ is the plastic strain rate. The first term represents strain hardening and the second term represents strain softening which is dependent on the adsorbed strain energy. They observed that the influence of the hardening term became negligible with increasing axial strain. Goughnour and Andersland reported excellent correlations between their model and data obtained on Ottawa sand

Ting (1983) proposed a simple empirical tertiary creep model for frozen sand, based on the model proposed by Assur (1979) for polycrystalline ice, of the form :

$$\dot{\varepsilon} = A \exp(\beta t)\, t^{-m} \qquad (2.24)$$

where A, β and m are experimentally determined constant defined as :

$$\beta = \frac{\ln(\dot{\varepsilon}_o/\dot{\varepsilon}_m)}{t_m \ln(t_m/t_o) + (t_o - t_m)} \qquad (2.25)$$

$$m = \beta t_m \qquad (2.26)$$

$$A = \frac{\dot{\varepsilon}_o\, t_o^m}{\exp(\beta t_o)} \qquad (2.27)$$

where $\dot{\varepsilon}_m$ = minimum strain rate

t_m = time to minimum strain rate

ε_m = strain at minimum strain rate

ε_o = strain at some initial nonzero time t_o=1 min

$\dot{\varepsilon}_o$ = strain rate at initial time t_o

Ting reported excellent correlation between his model and data on Manchester fine sand.

Gardner (1984), based on the constitutive equation proposed by Assur (1979) for polycrystalline ice, proposed a new equation which gave a good estimate of both creep strain and strain rate for the whole creep curve with an excellent fit up to inflection point. This equation is expressed as :

$$\frac{\varepsilon_c}{\varepsilon_m-\varepsilon_o} = \left(\frac{t}{t_m}\right)^c \exp\left[(vc-c)\left(\frac{t}{t_m}-1\right)\right] \qquad (2.28)$$

where c is the dimensionless parameter describing the shape of the curve and ε_m is the strain at t_m which is the time to reach minimum creep rate. ε_o is the initial strain and ε_c is the creep strain.

Yalin and Carbee (1983) proposed an equation of the following form which they claimed could describe the entire creep curve.

$$\varepsilon_{(t)}=\varepsilon_o+\frac{\varepsilon_f}{e^{\beta}t_m^{n-1}}\left(\frac{t}{t_m}\right)^{1-\beta}\exp(\beta t/t_m)\left[\frac{1}{(1-\beta)}-\frac{\beta t/t_m}{(1-\beta)(2-\beta)}+\frac{(\beta t/t_m)^2}{(1-\beta)(2-\beta)(3-\beta)}\right] \qquad (2.29)$$

where ε_o = instantaneous strain

$\beta = 0.33$ when $t_m < 30$ min.

$\beta = 0.23 t_m^{0.11}$ when $t_m \geq 30$ min.

t_m = time to reach minimum strain rate

$\varepsilon_f = \dot{\varepsilon}_m \, t_m^n$.

Although the creep models in the literature can describe a variety of creep behaviour, there is no comprehensive theory which considers creep rupture and eventual failure of the specimen during creep. In most cases long term strength models, which take into account the ruptures and failures, are described separately in the literature.

It is known that frozen soil flows, even under small stresses, if we consider this process on geologic time scale. The limiting long term strength for all practical purposes may be defined as the strength below which creep rupture or excessive deformation do not occur and reduction of strength with time become insignificant.

Vyalov (1962, 1966, 1973) described the long term strength of frozen soil by :

$$\sigma_\ell = \frac{\beta}{\ln[(t_f + t^*)/B]} \approx \frac{\beta}{\ln(t_f/B)} \qquad (2.30)$$

where β and B = temperature dependent soil parameters

t_f = time to failure

σ_ℓ = long term strength

$t^* = B \exp(\beta/\sigma_i)$

σ_i = instantaneous reference strength

Andersland and AlNouri (1976) observed that the confining pressure had little influence on the ultimate shear strength of frozen clay and that the long term angle of internal friction was found to be zero. An increase in shear strength occured with the increase in normal stress for sand-ice system giving a long term value of Φ=25.1°. This value of Φ was less than that would be expected for dry Ottawa sand with the same density. Parameswaran and Jones (1981) found that the angle of internal friction in frozen sand under confining pressure up to 90 MPa was only 12.4°; compared to 37° in unfrozen sand.

Sayles (1973) and Rogensack and Morgenstern (1978) suggested that the envelope for the frozen sand approached that of the unfrozen sand with time. Figure 2.24 shows that 3.2 hour and 22 hour envelopes are curved while 60 hour envelope is a straight line. The curved envelope for the shorter period of time indicates that the strength and the friction between the ice crystals dominate the strength of soil mass. The 60 hour straight line envelope suggests that the frictional resistance of the sand grains dominates the strength of the sand over long period. Sayles emphasized that for all practical purposes Mohr-Coulomb's expression (equation, 2.31) could be used for long term strength of sand with low ice contents.

$$\tau = c + \sigma_n \tan\Phi \qquad (2.31)$$

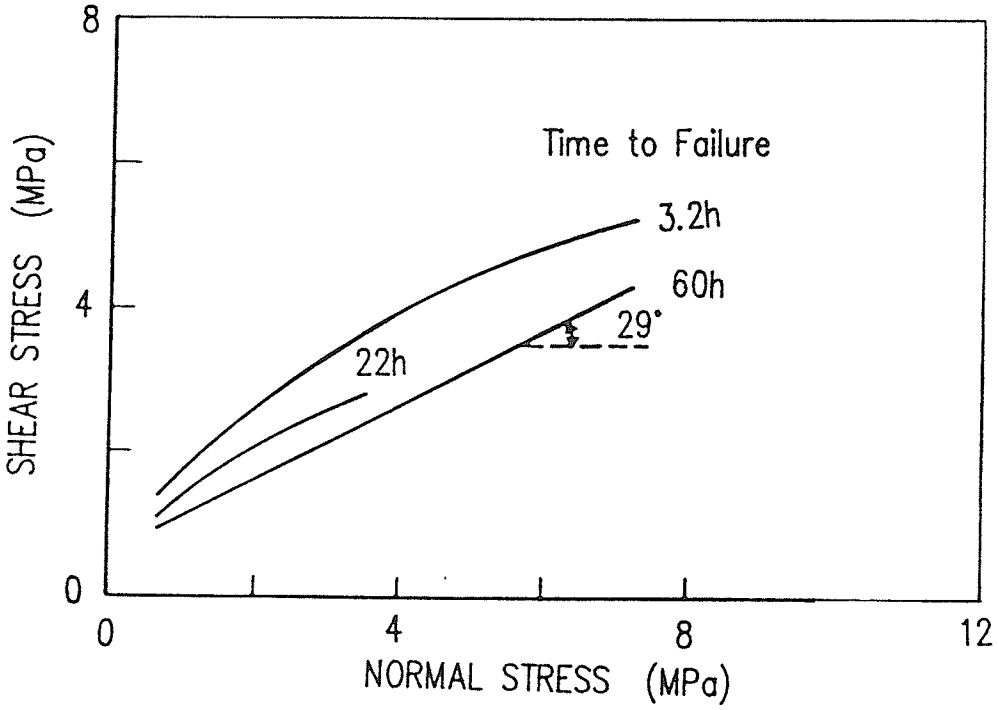


Figure 2.24 Mohr's envelopes for creep strength of Ottawa sand at −3.85°C (after Sayles, 1973)

where c = cohesion

σ_n = normal stress

Φ = angle of internal friction

Assuming the long term angle of internal friction for frozen sand is approximately equal to the friction angle of unfrozen sand, the strength of frozen sand according to equation (2.31) decreases with time due to a decrease in apparent cohesion.

Ladanyi (1972) expressed the strength at failure by :

$$(\sigma_1-\sigma_3)_f = \sigma_{fu}(t,0)+\sigma_3(f-1)(\dot{\varepsilon}_f/\dot{\varepsilon}_c)^{1/n} \qquad (2.32)$$

where σ_1 = major principal stress

σ_3 = minor principal stress

$\sigma_{fu} = \sigma_{cuo}(\dot{\varepsilon}_f/\dot{\varepsilon}_c)^{1/n}\ f(0)$

$\dot{\varepsilon}_f$ = strain rate at failure

$\dot{\varepsilon}_c$ = arbitrary strain rate

$$f = \frac{1+\sin\Phi}{1-\sin\Phi}$$

This equation implies a time dependent angle of friction if ε_f is kept constant or ε_f increases linearly with time, if the angle of friction is made independent of time. A simpler form may be obtained if only the strength and not the whole stress-strain behaviour is made dependent on normal pressure.

2.3 STRESS-STRAIN RELATIONSHIP

2.3.1 Deformation Parameters

The internal mechanical response of a material can be expressed in terms of stress and strains. The parameters which relate stresses and strains are generally defined as deformation parameters. For elastic, isotropic and homogeneous materials, it is necessary to know only two parameters, which may be either Young's modulus, E, and Poisson's ratio, , or bulk modulus, K, and shear modulus, G, to express stress-strain relationships. Since the behaviour of frozen soil is nonlinear and dependent on time, temperature, stress state, ice and unfrozen water content and other sample variations, the deformation parameters, E and , or K and G, are functions of these variables. Because of the complexity of the problem, previous researchers in the past have chosen to express axial strain as a function of the above variables and very little effort has been made to evaluate any of the deformation parameters for the frozen soils. For the unfrozen soils, extensive investigations have been carried out to study mainly the dependency of deformation parameters on the state of stress. Most of the literature on deformation parameters for frozen soils is drawn from the unfrozen soil mechanics to demonstrate how the deformation parameters are evaluated for nonlinear materials. The solutions available in the literature for the stress dependent deformation parameters may be broadly classified into the following categories :

i) E and ν from triaxial compression tests

ii) Direct determination of K and G

A brief review of each of the above methods is presented in the following sections.

2.3.1.1 E and ν from Triaxial Tests

Clough and Woodward (1967), based on the standard triaxial test, expressed the Young's modulus, E, and Poisson's ratio, , by the following :

$$E = \frac{(\sigma_1-\sigma_3)_i - (\sigma_1-\sigma_3)_{i-1}}{(\varepsilon_1)_i-(\varepsilon_1)_{i-1}} \qquad (2.33)$$

$$\nu = \frac{-1 + \sqrt{(1-8((E/2K)-1))}}{4} \qquad (2.34)$$

where $(\sigma_1-\sigma_3)$ = principal stress difference

ε_1 = axial strain

i = stage of increment of loading

K = bulk modulus assumed constant during loading

Skermer (1973) used the following expression in the finite element analysis of E. L. Infernillo dam.

$$E = \frac{d}{d\varepsilon_1}(\sigma_1-\sigma_3) \qquad (2.35)$$

$$\nu = \frac{1}{2}\left(1-\frac{d\varepsilon_v}{d\varepsilon_1}\right) \qquad (2.36)$$

where $\frac{d}{d\varepsilon_1}(\sigma_1-\sigma_3)$ = instantaneous slope of the curve $(\sigma_1-\sigma_3)$ vs ε_1

$\frac{d\varepsilon_v}{d\varepsilon_1}$ = instantaneous slope of the vol. vs axial strain curve

Duncan and Chaung (1970) and Clough and Duncan (1971) had shown that the tangent modulus, E, and Poisson's ratio, ν, could be approximated by some hyperbolic function where all the parameters were determined by triaxial tests.

2.3.1.2 Direct Determination of K and G

Newmark (1960) stated that it was often convenient to devide a general state of stress into two components : a) a state of hydrostatic stress accounting for the entire volumetric stress and strain and b) a deviator stress tensor accounting for shearing stress and strain.

Domaschuk and Wade (1969) proposed a method of obtaining K and G, by using isotropic compression test for K, and constant mean normal stress triaxial test for G. The basis of this approach is to separate the response under isotropic compression and under shearing stress. Data from triaxial tests on unfrozen soil (Konder and Zelasko, 1963), in which the mean normal stress was held constant, revealed that the stress-strain behaviour was nonlinear and was dependent on the magnitude of the mean normal stress.

Gill (1969), Liu (1970), and Stewart (1970) extended the

approach proposed by Domaschuk and Wade and obtained solutions for K and G for unfrozen Winnipeg clay. This approach was further developed by Valliappan (1974) for the Lake Agasis clay. Hanrahan (1985) followed the same approach of separating the stress system and obtained solutions for K and G for unfrozen soils.

The author's study is a continuation of the same approach with the objective of obtaining a generalized solution for K and G of the frozen sand. The parameters K and G are the functions of stress state, time, temperature, ice and unfrozen water content in addition to sample variation, grain size and other impurities. Because, K and G for frozen sand depend mainly on the creep behaviour, the parameters, henceforth will be defined as bulk creep function, K_c, and shear creep function, G_c. The theoretical considerations which form the basis of the direct determination of K_c and G_c are presented in the following sections.

2.3.2 Mean Normal and Deviatoric Components Stresses and Strains

The stress-strain relationship of a homogeneous, isotropic material exhibiting small strains when subjected to a general state of stress, can be expressed in terms of the bulk and shear moduli with tensor notations as follows :

$$\sigma_{ij} = K\varepsilon_{kk}\delta_{ij} + 2G(\varepsilon_{ij} - \frac{1}{3}\varepsilon_{kk}\delta_{ij}) \qquad (2.37)$$

where σ_{ij} = stress tensor

ε_{ij} = strain tensor

ε_{kk} = volumetric strain tensor

δ_{ij} = Kronecker delta

K = bulk modulus

G = shear modulus

Equation (2.37) can be separated into two components —— one in terms of mean normal components and the other in terms of deviatoric components. The equation in terms of mean normal components is given by :

$$\sigma_{ii} = 3K\varepsilon_{ii} \tag{2.38}$$

The equation in terms of deviatoric components is given by :

$$S_{ij} = 2G(\varepsilon_{ij} - \frac{1}{3}\varepsilon_{kk}\delta_{ij}) \tag{2.39}$$

where S_{ij} = deviatoric stress tensor

$(\varepsilon_{ij}-(1/3)\varepsilon_{kk}\delta_{ij})$ = deviatoric strain tensor

The deviatoric stress tensor can be expressed by :

$$S_{ij} = \sigma_{ij} -(1/3)\sigma_{kk}\delta_{ij} \tag{2.40}$$

in which $(1/3)\sigma_{kk}$ is the mean normal stress.

The deviatoric stress tensor is a second order symmetric tensor and it is important to note that the first invariant of deviatoric stress tensor is always zero. The principal directions of the deviatoric stress tensor are the same as for the original stress tensor.

The general state of stress at a point may be represented by the three principal stresses and their direction cosines. The magnitude and direction of each of these principal stresses can be represented by vectors acting on the face of a cube of an element of soil, as shown in Figure 2.25. These principal stresses can be separated into components of mean normal stress and deviatoric stress. The mean normal stress, σ_m, which imposes a uniform stress on the element (Figure 2.25b), is the average of the three principal stresses. Subtracting the mean normal stress from each of the principal stress gives the deviatoric stress components S_1, S_2 and S_3 as shown in Figure 2.25c. The three deviatoric stress components can be combined and represented by their resultant, S_d. The components of stresses, σ_m and S_d, are given by :

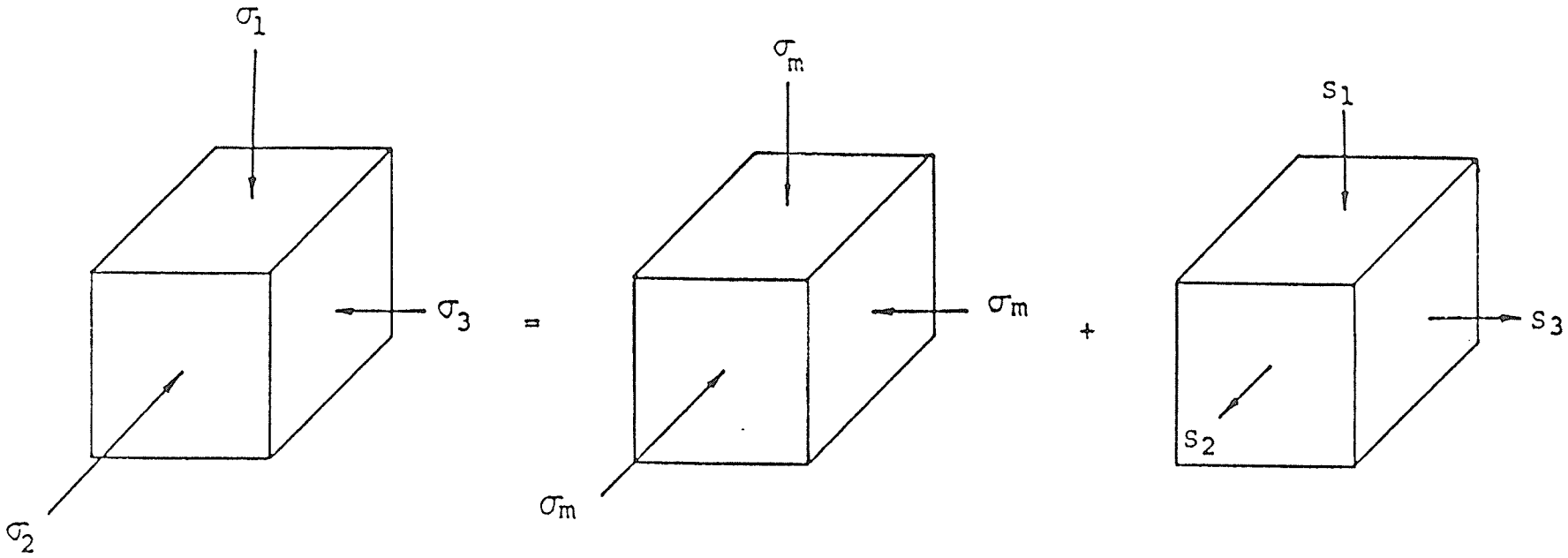
$$\sigma_m = \frac{\sigma_1+\sigma_2+\sigma_3}{3} \qquad (2.41)$$

$$S_d^2 = S_1^2 + S_2^2 + S_3^2 \qquad (2.42)$$

in which $S_1 = \sigma_1 - \sigma_m$

$S_2 = \sigma_2 - \sigma_m$

$S_3 = \sigma_3 - \sigma_m$



Principal Stress System

(a)

Mean Normal Stress Components

(b)

Deviatoric Stress Components

(c)

Figure 2.25 Nomenclature for stress system

The general state of strain in an element can be represented by the three components of principal strain and their direction cosines.This state of strain can further be separated into the volumetric strain associated with the mean normal stress and the deviatoric strain associated with the deviatoric components of the stress. As in the case of stress system, the mean normal strain, ε_m, and the resultant deviatoric strain, ε_d, are given by :

$$\varepsilon_m = \frac{\varepsilon_1+\varepsilon_2+\varepsilon_3}{3} \qquad (2.43)$$

$$\varepsilon_d = 2/3((\varepsilon_1-\varepsilon_m)^2+(\varepsilon_2-\varepsilon_m)^2+(\varepsilon_3-\varepsilon_m)^2) \qquad (2.44)$$

In terms of mean normal stress and mean normal strain the equation (2.38) becomes :

$$\sigma_m = 3K\varepsilon_m \qquad (2.45)$$

The resultant deviatoric stress and strain components are related by the shear modulus, G, in accordance with the equation (2.46).

$$S_d = G\varepsilon_d \qquad (2.46)$$

Thus the stress-strain system at a point may be separated into two separate components, each associated with a distinct component of behaviour. For elastic solids there exists unique relationships between the parameters, K and G, and the parameters, E and ν. It is

found in the literature that the experimental investigation to evaluate the parameters, E and ν is not unique but varies with the application of stress system. The advantage, however, of using G and K rather than E and ν is that the former moduli may be evaluated independently and may be more readily related to the stress system.

The parameters, G and K are simple, single valued quantities for a linear elastic material. For real materials, especially for the frozen sand, they are complex quantities which must be evaluated from the appropriate laboratory tests. In this study the elastic bulk modulus, K, will be replaced by bulk creep function, K_c, as a function of time, temperature, mean normal stress and ice content :

$$K_c = f(t, T, \sigma_m, i_c) \qquad (2.47)$$

and the elastic shear modulus, G, by shear creep function, G_c, as a function of time, temperature, mean normal stress, resultant deviatoric stress and ice content :

$$G_c = f(t, T, \sigma_m, S_d, i_c) \qquad 2.48)$$

CHAPTER THREE
LABORATORY INVESTIGATION

CHAPTER 3

LABORATORY INVESTIGATION

3.1 SCOPE OF INVESTIGATION

An understanding of the behaviour of frozen soils, under the changes of isotropic stress and deviatoric stress, is essential to the formulation of a valid constitutive law which establishes the relationship between the stresses and strains in the soil mass. The main objectives of the investigation were to obtain deformation moduli of frozen soils in functional form which would relate stresses, strains and time, and to understand the mechanics of frozen soil behaviour.

The testing program consisted of multi-stage isotropic creep tests, constant mean-normal-stress triaxial creep tests, and stress controlled constant cell pressure triaxial creep tests. A multi-stage isotropic creep test with isotropic pressures ranging from 50 to 300 kPa, was performed in order to establish a functional relationship for the bulk creep function. A total of 9 multi-stage constant mean-normal-stress triaxial compression creep tests were performed with mean normal stresses varying between 70 and 420 kPa, to establish a functional relationship for the shear creep function. A total of 4 multi-stage stress controlled constant cell pressure triaxial creep tests were performed to verify the model developed on the basis of the

isotropic and constant mean- normal-stress triaxial tests. The details of the tests are given in subsequent chapters.

A strict sample preparation technique as outlined in the following sections was followed using a quartz-carbonate sand in order to obtain as identical sample as possible. Low pressure ranges were used to simulate conditions normally observed in the field.

3.2 SAMPLE PREPARATION

3.2.1 Frozen Sand Sample

The frozen sand samples used in the investigation were prepared in the laboratory. A specific sample preparation technique outlined in the following sections was followed in an attempt to achieve samples with identical densities and water/ice contents.

The soil used was uniform, quartz-carbonate medium-grain sand with a uniformity coefficient (D_{60}/D_{10}) of 2.0. The grain size distribution of the sand is shown in Figure 3.1. The sand had a specific gravity of 2.70.

Sample preparation involved three stages, namely, i) sand deposition, ii) saturation, and iii) freezing. These stages are described in the following sections.

3.2.1.1 Sand Deposition

A plexiglass split mold with two end caps, 76 mm in diameter and 200 mm in height (Figure 3.2) was first assembled and the inside of the mold was properly greased to avoid any bond between the sample and the mold. Care was taken to clean and place all the O-rings and seals in place to ensure air and water tight joints and connections. A saturated porous stone was set up, under water, on the base plate. The sand was poured into the mold through a free fall device at a constant rate, while maintaining a constant height of fall of 25 mm. The sand was filled to a height of 15 mm from the top of the mold. A porous stone was placed on top of the sand and the top cap was put into place. An approximately constant density with a maximum variation of 7 percent between samples was achieved and the technique was reproducible. The dry density ranged between 15.2 and 15.8 kN/m^3.

3.2.1.2 Saturation

A schematic set-up of the saturation process is shown in Figure 3.3. All connections were checked and the water lines were saturated by circulating water through them. Deaired distilled water was used in the saturation process. Each sample was saturated under a vacuum pressure of 55 kPa applied at the top, with access to distilled water through a porous stone at the bottom. The water was supplied at a constant rate of 2 ml/min by adjusting the valve every 10 minutes. A burette, on line, was used to check the flow of water into the sample. This process allowed sufficient time to draw almost all the air from

within the specimen under a vacuum pressure of 55 kPa. This process of specimen saturation was achieved through experience and trial by the author and others who helped to develop the process.

At least 0.5 litres of additional water was circulated through the specimen to ensure further removal of any air bubbles entrapped in the sample. The whole process took about five hours. At the end of saturation, the water supply valve was closed and the suction was released very slowly. The top cap was removed and the water level in the mold was lowered to the top surface of the porous stone. The relative level of the porous stone to the base was recorded to determine if any heaving occured during the freezing process. The top cap was then put into place.

3.2.1.3 Freezing

It is well known that when a saturated soil sample is frozen, it increases in volume by about 9 percent of the volume of water present in the sample. After saturation and replacing the top cap , a thin access tube was attached to the fixture at the top cap to allow dissipation of any pressure built-up by the release of gas from within the sample. The whole assembly of the mold was placed in a wooden box with a circular opening at the bottom to allow the mold to protrude by about 20 mm at the bottom. The box was then filled with vermiculite which insulated all of the mold except the bottom 20 mm of the mold. The assembly consisting of the box and the mold was placed in a chest freezer in which the temperature was maintained at -20°C. The samples

were frozen unidirectionally from the bottom to the top in a period of about 48 hours.

The average freezing rate was 3.5 mm per hour. No ice lensing was observed in any of the samples when examined later. Some excess ice, due to the expulsion of water during the freezing process, formed at the top of the samples and was subsequently removed by trimming.

3.3 TESTING EQUIPMENT

3.3.1 Triaxial Cell

Double-walled alluminum triaxial cells similar to that used by Mitchell and Burn (1971) and Baker et al. (1981) were modified and used in all the tests. A schematic of the set-up including the volume change measurement device is shown in Figure 3.4. A schematic of the double-walled cell is shown in Figure 3.5.

The triaxial cell consisted of two aluminum cylinders sitting axisymmetrically on a base. The sample was placed inside the inner cylinder on a pedestal. The cylinders were capped separately so that the inner cylinder with the cap was contained wholly within the outer cylinder. A volume change measurement device was connected with the inner cylinder. During the test both the inner and outer cylinders were filled with antifreeze. Any change in volume of the sample inside the inner cylinder was reflected in the level of antifreeze in the

volume change measurement device. O-rings as shown in Figure 3.5 were provided to seal various components of the cell. Copper cooling coil, wrapped around the inner cell, was used to circulate cooling fluid to minimize temperature variations in the sample due to the variations in the room temperature during the defrosting cycle.

During testing, the cell pressure was supplied by a pressurized bottle of dry nitrogen gas through a high precision, two stage regulator. Equal pressure was maintained in both the inner and outer cylinders through a T-connection in the pressure line as shown in Figure 3.4. The cell pressure was monitored by a pressure transducer and was double checked with a pressure gauge fitted to the pressure regulator.

A thermistor of the type OMEGA 44203 was mounted in the inner cell to monitor the temperature of the inner cell fluid. The thermistor was calibrated against a precision thermometer, accurate to one-hundredth of a degree in Celcius scale. Each thermistor was connected with the electronic readout device for regular monitoring during the test.

A Volume change measurement device was designed to measure the volume displacement of the inner cell fluid by using a double-walled burette sometimes called a back pressure burette. A burette was preferred to an electronic device because of its simplicity, accuracy and reliability.

The assembly of the triaxial cell was calibrated for creep due to axial load using a dummy cylindrical steel block sample and the antifreeze was calibrated for volume change with isotropic cell pressure.

3.4 SAMPLE TRIMMING AND SETTING-IN PROCEDURE

The mold containing the frozen sample was taken out of the freezer and carried to the cold room which was maintained at a temperature of -3°C. The sample was then removed from the plexiglass mold,placed in a steel split mold and was trimmed to the required length using a band saw. The trimmed end was then smoothened, the sample was removed from the split steel mold and was weighed. Trimmings were collected for determining the ice content of the sample.

Two dry porous stones were placed on the pedestal of the triaxial cell. The trimmed sample was placed with the trimmed end down, on the porous stones. A top cap was placed on the top end porous stone which was built in during the sample preparation.

The sample was then placed in a rubber membrane and O-rings were used to seal the ends. The inner cell was put in place and bolted at the bottom with the base plate. The cooling coil was connected to the fixure at the base plate. The top cap of the inner cell was replaced and bolted with the top end flange. The outer cylinder was placed and bolted in with the base plate. The piston was then inserted

into the top cap of the inner cylinder.

Both the inner cell and the outer cell were filled with antifreeze which was brought to the test temperature at least 24 hours prior to the filling. The filling of the inner cell was completed when the antifreeze started bleeding through a port on the top cap of the inner cell. The bleed valve was plugged with a brass nut. The top cap of the outer cell was then replaced and bolted on to the top flange of the outer cell. The rest of the outer cell was then filled until it started bleeding through a valve at the top of the outer cell cap.

A small amount of pressure, about 10 kPa, was applied to check for any leakage in the system. If no leakage was found, the system was ready for loading.

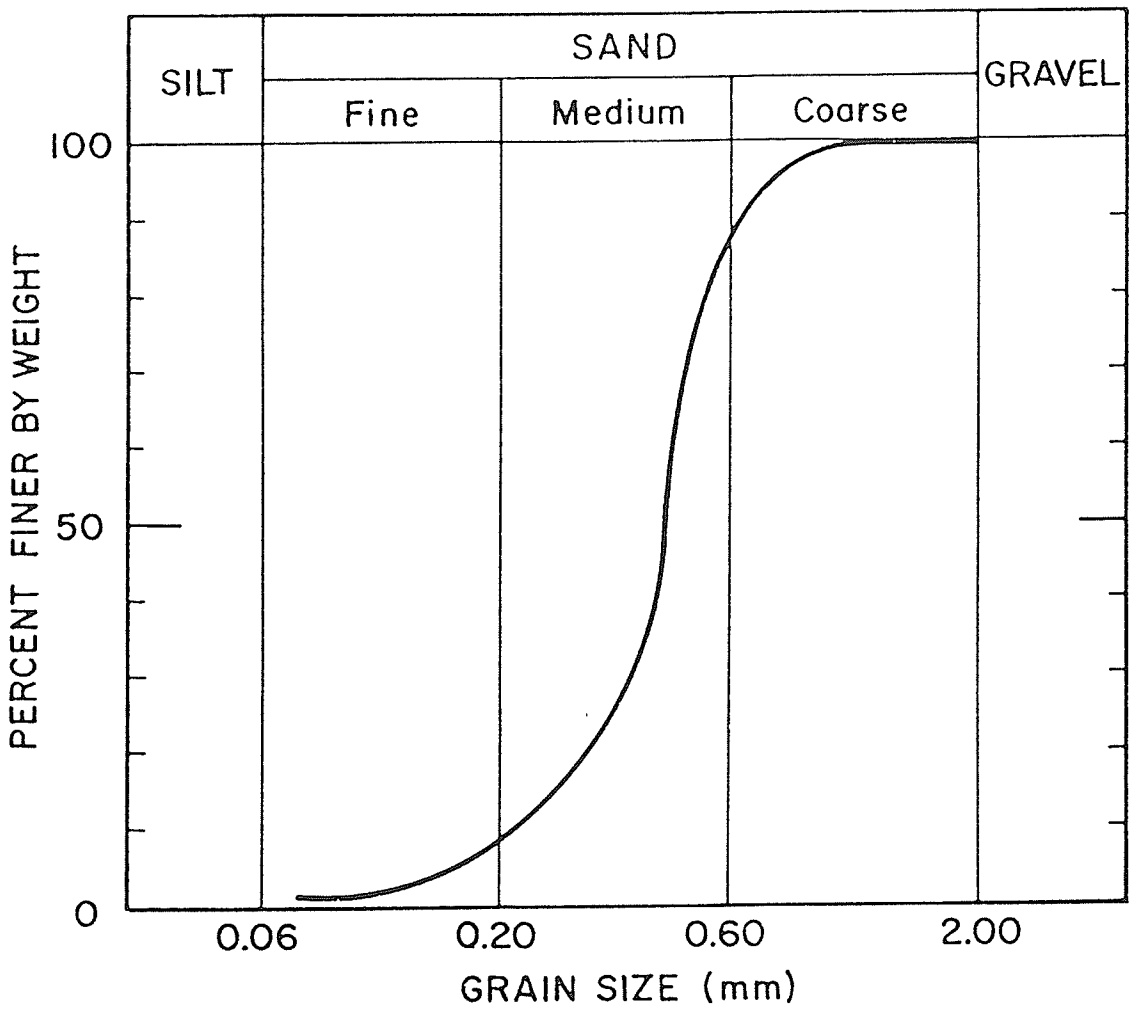


Figure 3.1 Grain size distribution of the sand

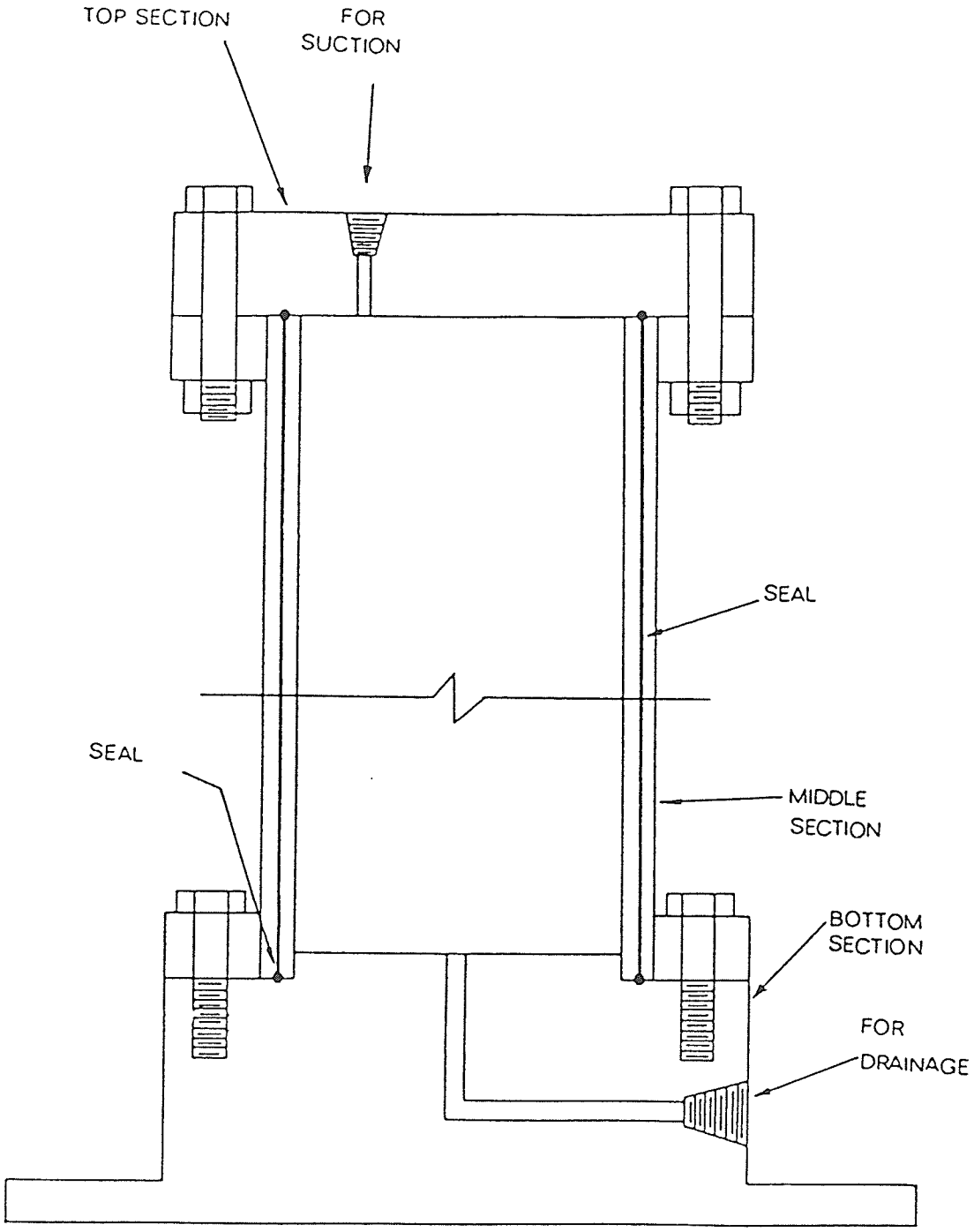


Figure 3.2 Plexiglass mold (not to scale)

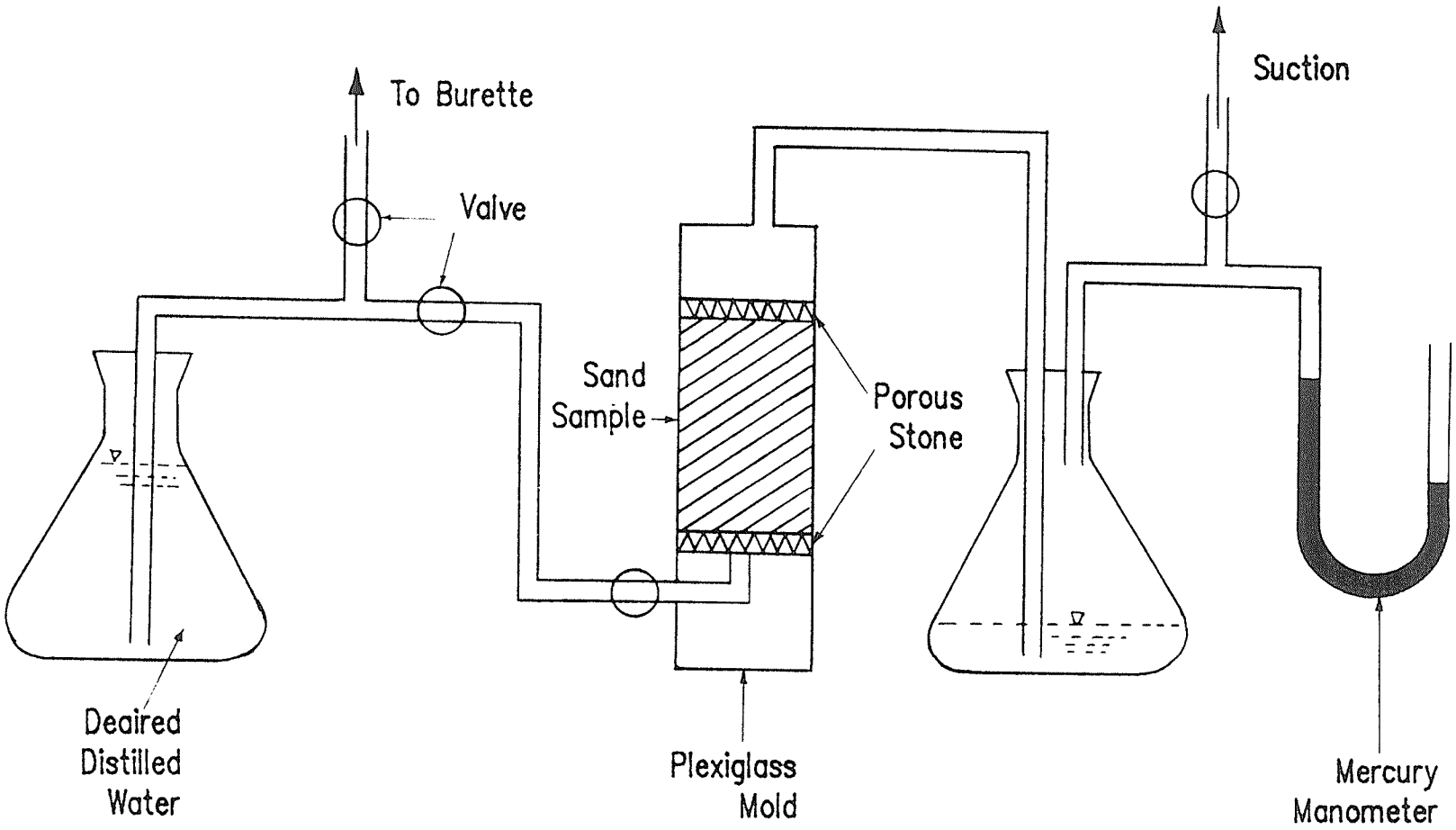


Figure 3.3 Schematic diagram of saturation process of the sand sample

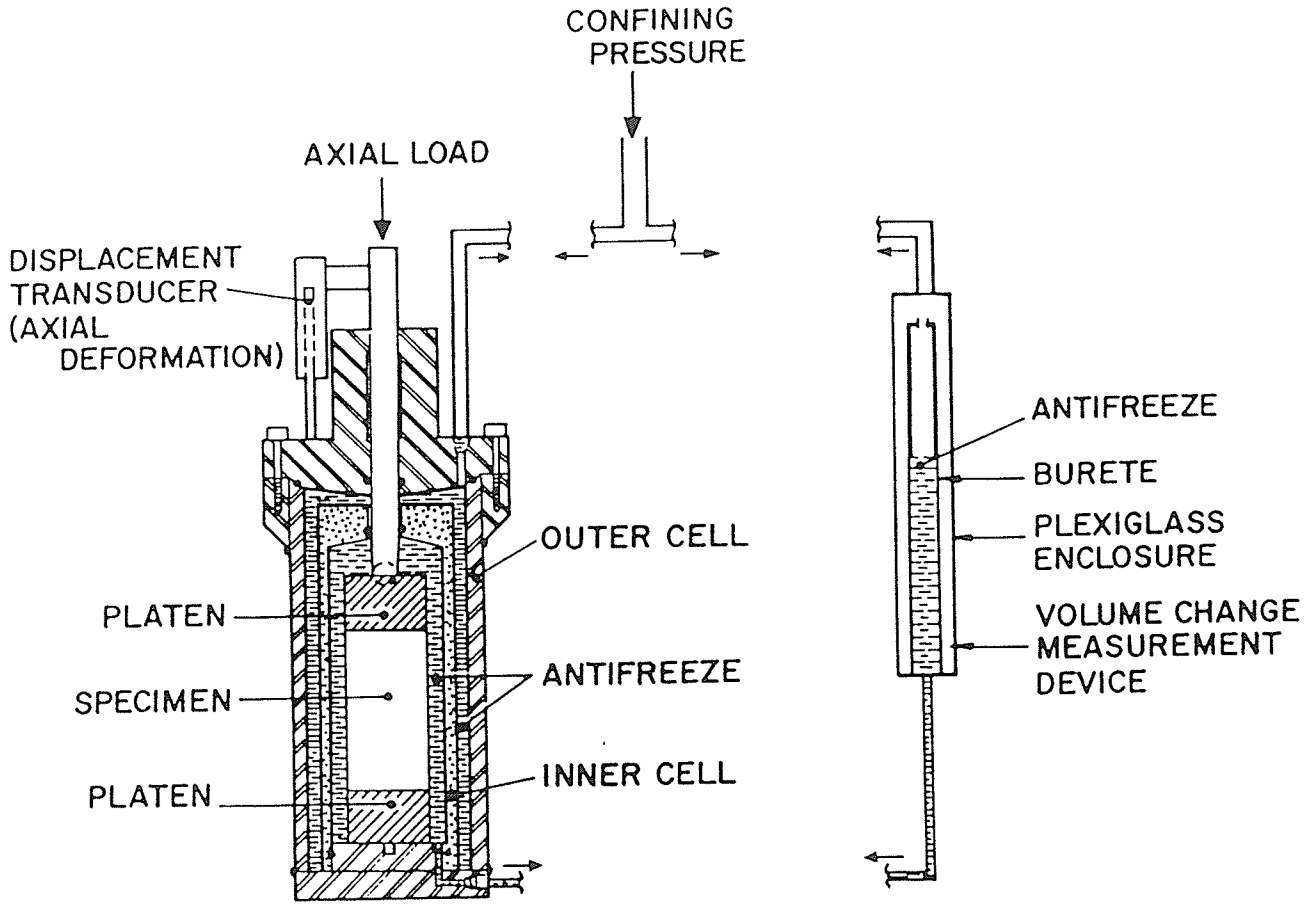


Figure 3.4 Schematic diagram of the triaxial cell

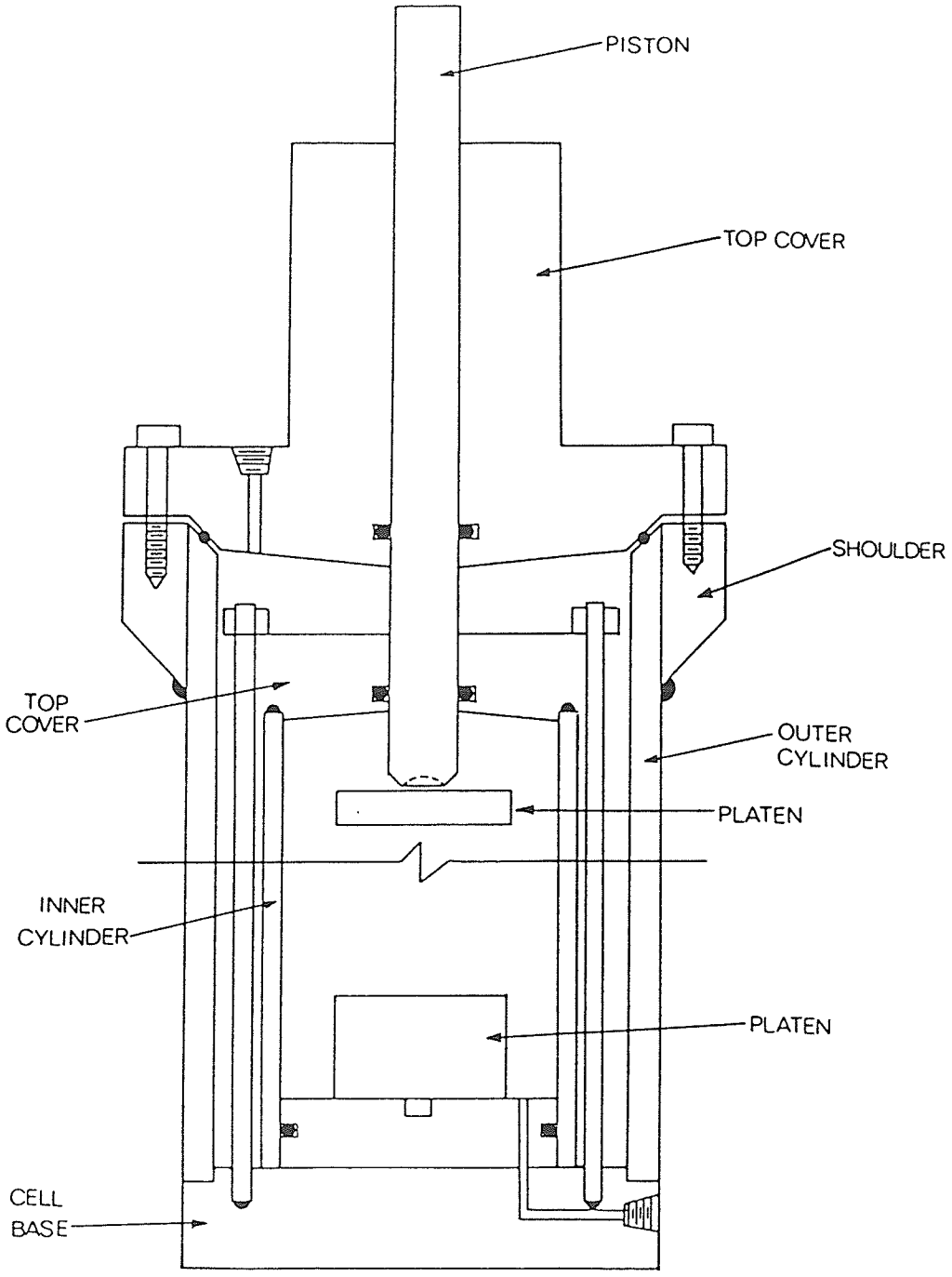


Figure 3.5 Triaxial cell details (not to scale)

CHAPTER FOUR
BULK CREEP FUNCTION

CHAPTER 4

BULK CREEP FUNCTION

4.1 INTRODUCTION

As mentioned in Chapter 3, formulation of a valid constitutive law for a frozen soil and a better prediction of the relationship between stress and displacement in the frozen soil mass require an understanding of the behaviour of the frozen soil under isotropic stress changes. The stress-strain data obtained from isotropic compression tests are particularly useful in the direct determination of bulk creep function. The bulk creep function, K_c, as given by equations 2.45 and 2.47, relates the isotropic stress, σ_m, and the associated volume change, ε_v, of a frozen soil element. Since the relationship is nonlinear, the bulk creep function is defined as :

$$\frac{d\sigma_m}{d\varepsilon_m} = K_c = \lim_{\Delta\varepsilon_v \longrightarrow 0} \left(\frac{\Delta\sigma_m}{\Delta\varepsilon_v}\right) \qquad (4.1)$$

The bulk creep function depends on many factors, such as, temperature, time, stress level, ice content, unfrozen water content and mineralogical composition of the soil. In the investigation, the index properties of the frozen sand sample and the temperature were held constant and the bulk creep function was investigated as a function of mean normal stress and time.

4.2 TEST PROCEDURE

A single multi-stage isotropic consolidation test, IC1, was conducted to determine the relationship between isotropic stress and volumetric creep strain. After the sample was set up, as outlined in Chapter 3, a 24-hour period was allowed before any load application, to bring the sample and the system into temperature equilibrium. The cell pressure was applied by bottled nitrogen gas and the pressure was monitored by a pressure transducer and double checked by a pressure gauge mounted on the high precision two stage regulator. Equal pressure was maintained in both the fluid in the inner cell and in the outer cell so that the inner cell was not subjected to any volume change due to changes in the cell pressure. The volume change of the sample was measured by measuring the change in volume of the fluid in the inner cell using a burette.

The test was started with a stress increment of 50 kPa. Volume change and axial deformation of the sample were recorded at frequent intervals. The stress was held constant until the volumetric strain approached an asymptotic value which occurred after about 300 hours. The isotropic stress was then increased to 100 kPa and subsequently to 150, 200, and 300 kPa. Each stress level was maintained until the volumetric deformation appeared to be close to its asymptotic value for that particular stress level. Because complete attenuation takes an inordinate length of time to achieve, it was considered to be

impractical to wait until there was no further change in volume. Generally it was assumed that complete attenuation occurred if the volumetric strain was of the order of 10^{-9}/sec. The stress steps of 100, 150, 200, and 300 kPa were maintained for 216.5, 527.5, 1247.5 and 2159.5 hours respectively. The test took almost 200 days to complete.

4.3 TEST RESULTS AND DISCUSSIONS

4.3.1 Volumetric Stress-strain Relationship

Plots of cumulative true volumetric strain versus cumulative time are presented in Figure 4.1 along with the magnitude of isotropic stress at each increment. The true volumetric strain differs from conventional engineering volumetric strain in that each increment of strain is based on the actual volume at the time of the increment, instead of the original volume. The true volumetric strain is given by:

$$\varepsilon_v = \int_{V_o}^{V_t} \frac{dV}{V} = \ln \frac{V_t}{V_o} \qquad (4.2)$$

in which dV = change in volume

V_t = volume of the sample at time t

V_o = volume of the sample at time t=0

Individual plots of true volumetric strain versus time for each stress increment are shown in Figure 4.2. The final volumetric strain

for one stress increment was plotted as the initial volumetric strain for the subsequent stress increment and thus the volumetric strains shown are cummulative.

From the plots of Figure 4.1 and 4.2 it was observed that typically for each application, there was an instantaneous volumetric strain followed by time-dependent volumetric strain, the rate of which decreased with time. The time for attenuation (negligible strain rate) increased from about 300 hours for the initial stress increment to about 2000 hours for the final stress increment. The cumulative attenuated volumetric strains varied from about 0.8 to 2.9 percent for the 50 to 300 kPa isotropic stress range.

The cumulative instantaneous and attenuated volumetric strains are shown in Figure 4.3 which is a plot of volumetric strains versus the isotropic or mean normal stress. It is seen that practically all of the instantaneous strain, (95%), occurred during the first stress application with only a slight, approximately linear, increase in volumetric strain with stress level. When the sample was unloaded at the end of the iosotropic compression test, the recovery was immeasurable, indicating that all the strains were of inelastic compression.

The relationship between the attenuated volumetric strains and the mean normal stress was approximately linear for the stress range investigated. A significance of this relationship is that its slope provides an ultimate or attenuated, psuedo-elastic bulk modulus, K_∞ .

For the test conditions the attenuated bulk modulus was determined to be:

$$K_{\infty} = 10{,}250 \text{ kPa} \qquad (4.3)$$

The difference between the instantaneous and attenuated volumetric strain represents creep strains which are seen to increase with stress level.

4.3.2 Influence of Time and Mean Normal Stress on Volumetric Strain Rate

The variation in volumetric strain rate with time for each increment of mean normal stress is shown in Figure 4.4. For each stress level the relationship between strain rate and time consisted of a curve which is asymptotic to the ordinate and the abscissa. At time t=0 the strain rate approaches infinity reflecting the instantaneous response of the soil to a stress change. At time t=∞ the volumetric strain rate approaches zero reflecting the attenuation of volumetric creep.

The relative positions of the curves indicate that generally the creep rate increased with an increase in mean normal stress for elapsed time greater than about 250 hours. The mean normal stress also had a major influence on the "attenuated time", t_{∞}, and the magnitude of the attenuated volumetric strain. A plot of mean normal stress versus attenuated-time is shown in Figure 4.5. It is seen that the

attenuation time increased exponentially with stress.

4.3.3 Solution for Bulk Creep Function

The bulk creep function relates mean normal stress to volumetric strain and as defined earlier, is the instantaneous slope of the volumetric stress-strain curve. The volumetric stress-strain curves could not be obtained directly from the multi-stage isotropic creep tests in which the stress at every step was maintained constant and deformations were recorded with time and the results were obtained in the form of volumetric strain versus time for various mean normal stresses. Therefore it became necessary to obtain the volumetric strain versus mean normal stress relationship for various times from the data obtained in the multi-stage isotropic creep tests. The relationship between mean normal stress and volumetric strain after various elapsed times are shown in Figure 4.6. These curves were constructed from the data obtained from the multi-stage isotropic consolidation test as presented in Figures 4.1 and 4.2. The total strain at any particular time was assumed to be the sum of all the instantaneous strains and the creep strains which the sample had undergone prior to the time under consideration. The curves in Figure 4.6 are straight lines in the transformed plot of σ_m/ε_v versus σ_m as shown in Figure 4.7 and therefore can be represented by equation (4.4) as follows:

$$\frac{\sigma_m}{\varepsilon_v} = K_{cm} = K_o + \beta\sigma_m \qquad (4.4)$$

in which ε_v = accumulated true volumetric strain

σ_m = mean normal stress (isotropic stress)

K_{cs} = secant bulk creep function

K_o = intercept on σ_m/ε_v axis

β = slope of the straight lines

The intercept on the σ_m/ε_v axis provides the initial value K_o of the bulk creep function in the relationship between the secant bulk creep function, K_{cs}, and the mean normal stress. Thus it represents a minimum value of the secant bulk creep function i.e. for $\sigma_m=0$. Its value was 10250 kPa which is the same as the attenuated bulk creep function, K_∞. This is to be expected since K_∞ also represents the minimum value of the bulk creep function based on attenuated volumetric strains. Thus in Figure 4.7, the relationship between K_{cs} and σ_m is a horizontal line for $t=\infty$ which is consistent with equation (4.3).

The parameter β was plotted as a function of time in Figure 4.8 and the relationship was represented by the following equation.

$$\beta = ne^{-mt} \qquad (4.5)$$

in which m & n = material constants

t = time (hour)

For the tests these constants were:

n = 180

m = 0.0045

Thus the equation for the secant bulk creep function may be written as:

$$K_{cs} = K_o + ne^{-mt}\,\sigma_m \tag{4.6}$$

Equation (4.6) for the test data can be rewritten as:

$$K_{cs} = 10250 + 180\,e^{-0.0045t}\,\sigma_m \tag{4.7}$$

To obtain an expression for the tangent bulk creep function, K_{ct}, equation (4.4) is rewritten as:

$$\varepsilon_v = \frac{\sigma_m}{K_o + \beta\sigma_m} \tag{4.8}$$

The first derivative of equation (4.8) provides the inverse of the tangent bulk creep function, K_{ct}, as follows:

$$\frac{1}{K_{ct}} = \frac{d\varepsilon_v}{d\sigma_m} = \frac{K_o}{(K_o + \beta\sigma_m)^2} \tag{4.9}$$

or

$$K_{ct} = \frac{(K_o + \beta\sigma_m)^2}{K_o} \tag{4.10}$$

Substituting the expression for β (equation 4.5) into equation (4.10), the equation for the tangent bulk creep function, K_c, becomes:

$$K_{ct} = K_o\,(1 + \frac{1}{K_o}\,ne^{-mt}\sigma_m)^2 \tag{4.11}$$

which for the test data becomes:

$$K_{ct} = 10{,}250\ (1 + 1.756\text{x}10^{-2}\ e^{-0.0045t}\sigma_m)^2 \qquad (4.12)$$

Time, t, and mean normal stress, σ_m, in equation (4.12) are expressed in hour and kPa respectively. According to equation (4.12), the tangent bulk creep function, K_{ct}, increases exponentially with an increase in the mean normal stress. This is illustrated by a plot of K_{ct} versus σ_m for selected elapsed times in Figure 4.9. On the other hand, as shown in Figure 4.10, the tangent bulk creep function decreases exponentially with time for a constant mean normal stress. At time $t=\infty$, the second term of the equation reduces to zero and K_{ct} is equal to K_o which is also equal to K_∞.

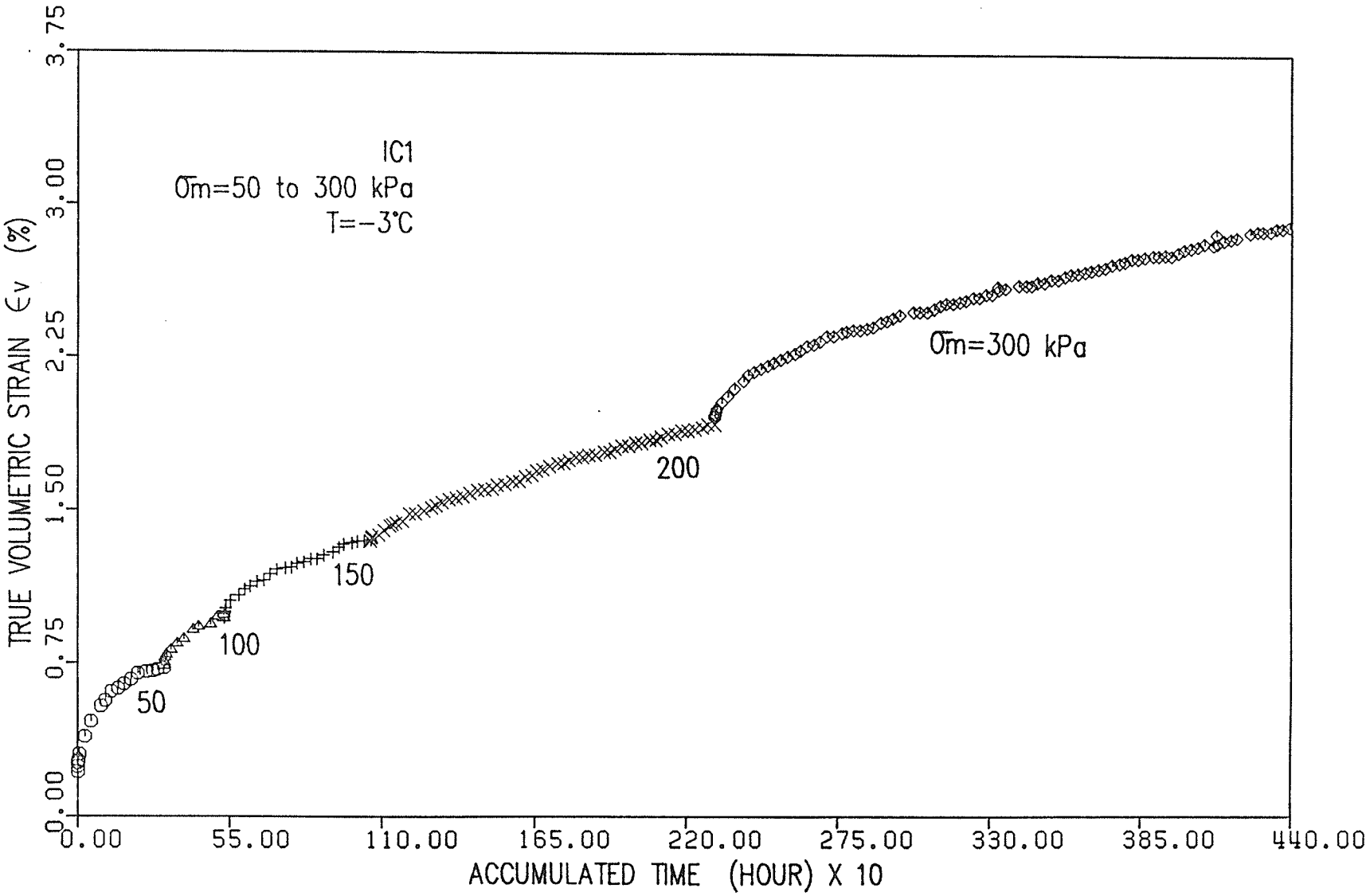


Figure 4.1 True volumetric strain as a function of accumulated time

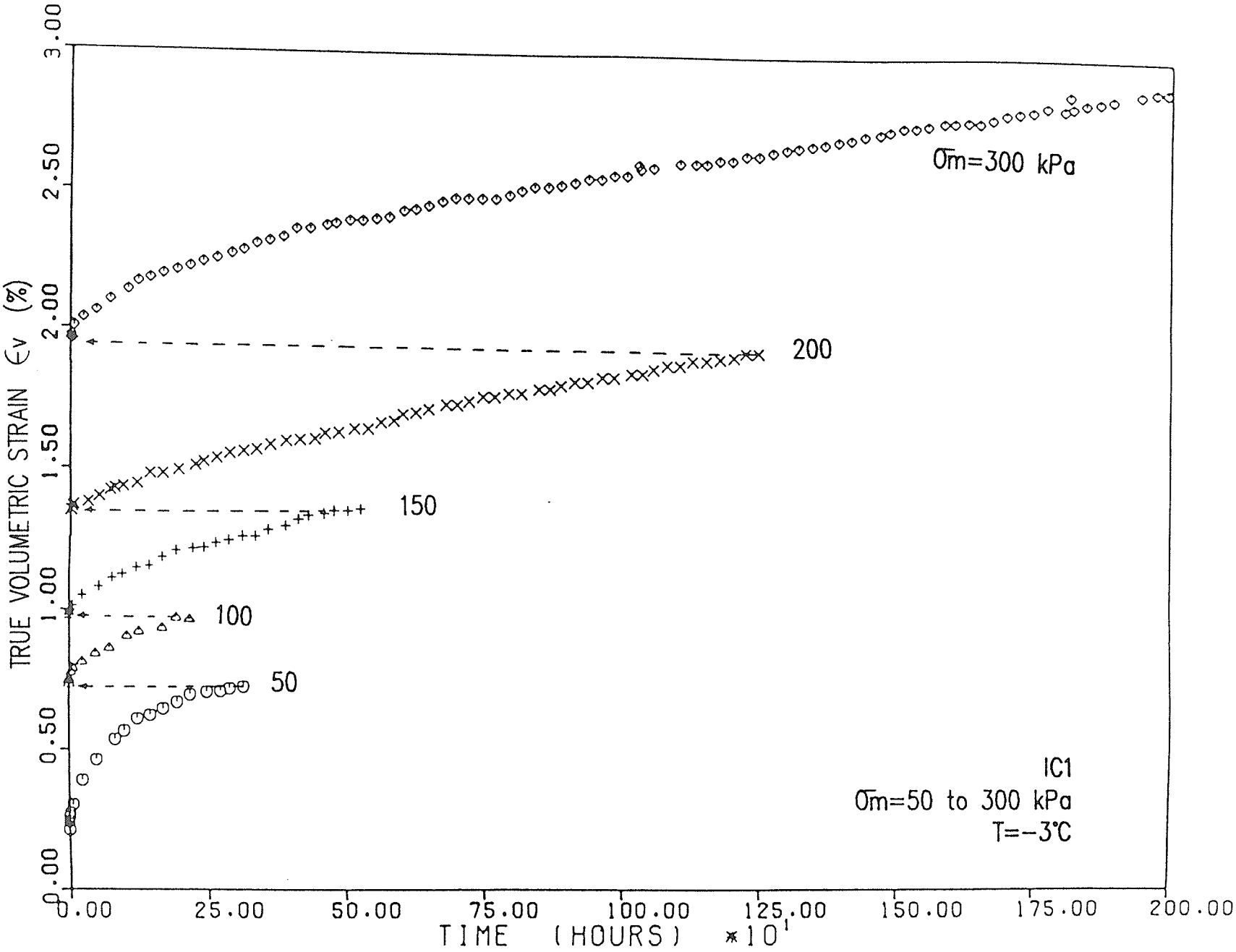


Figure 4.2 True volumetric strain versus time

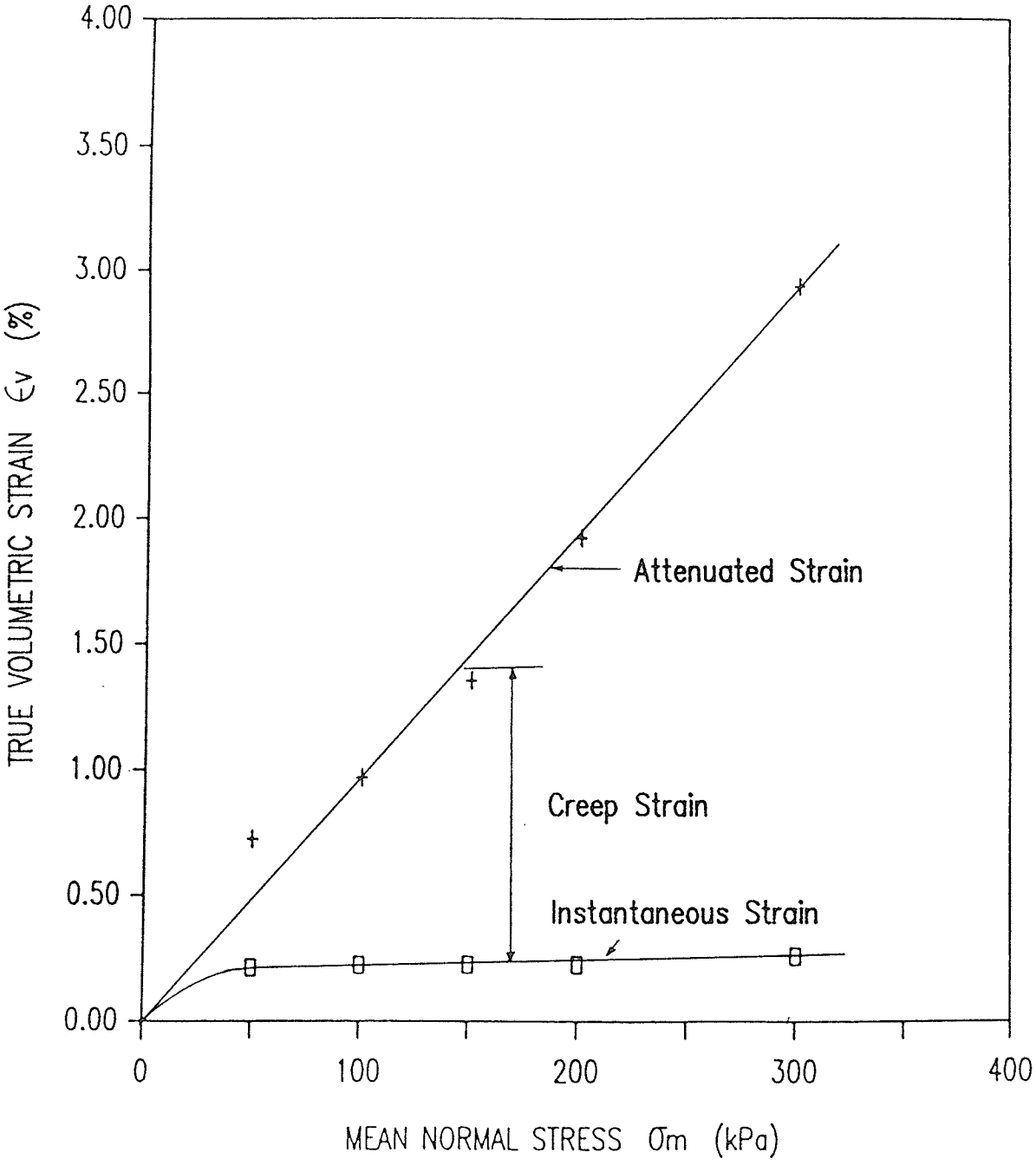


Figure 4.3 True volumetric strain versus mean normal stress

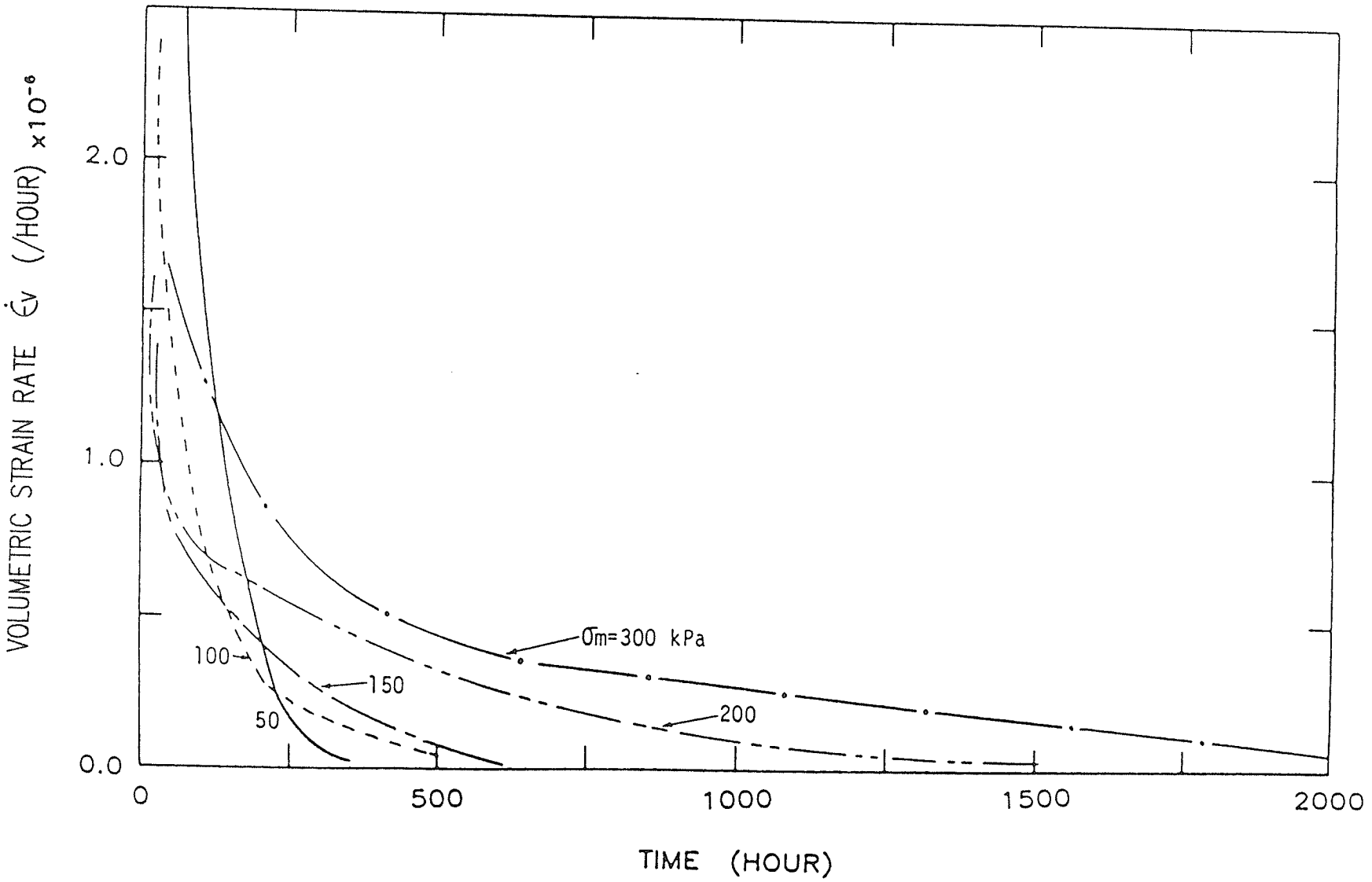


Figure 4.4 Volumetric strain rate versus time

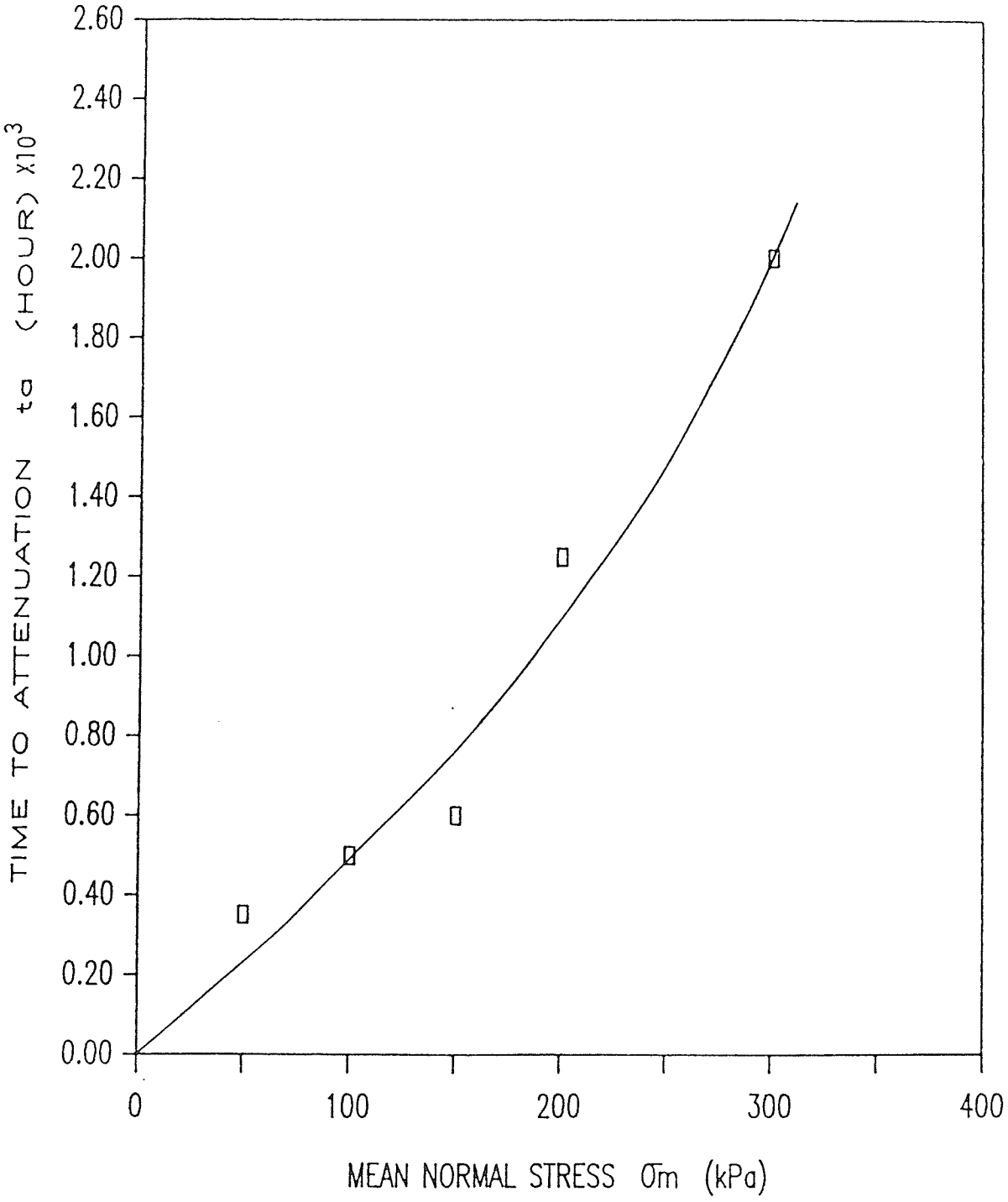


Figure 4.5 Time to attenuation versus mean normal stress

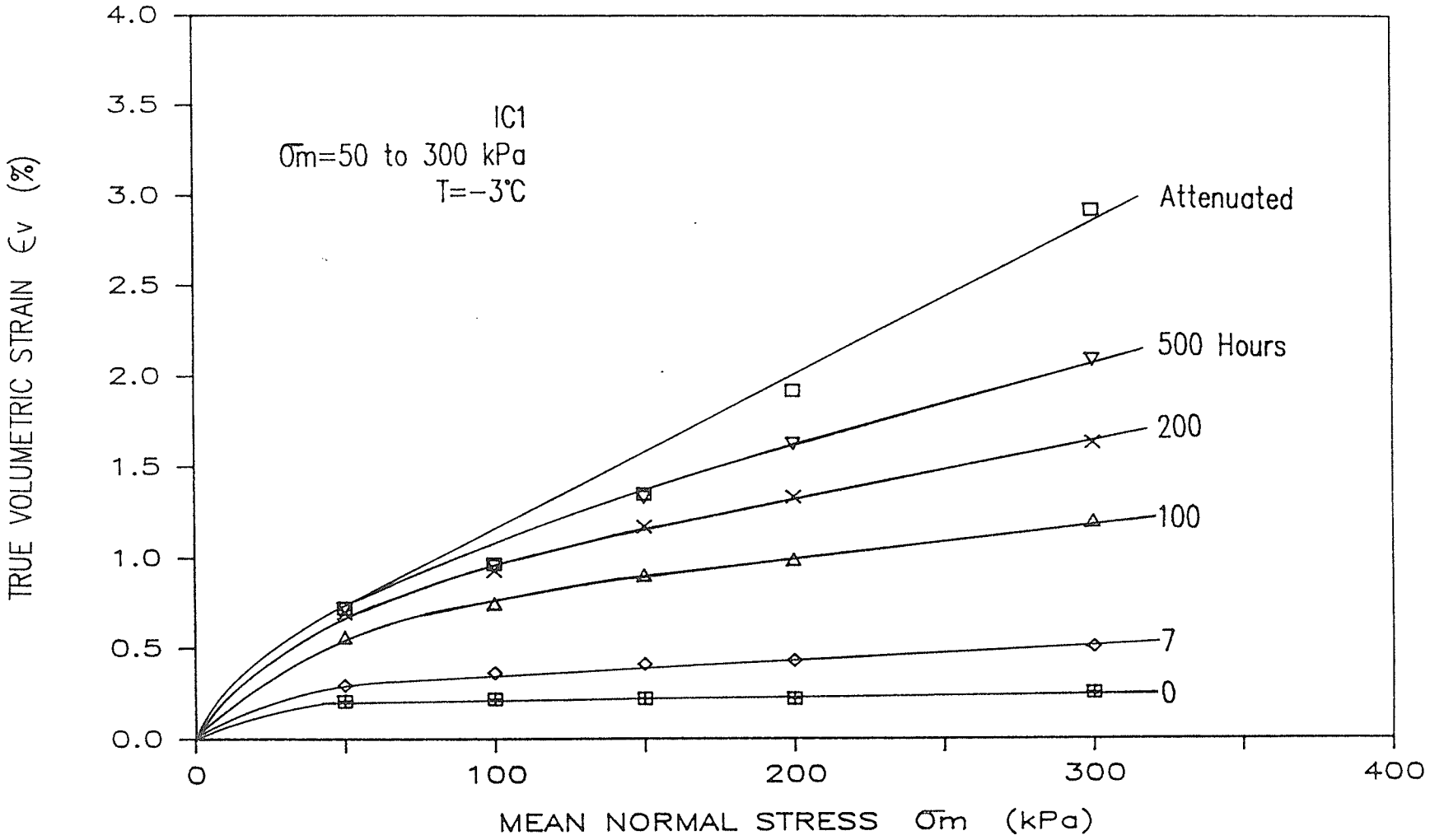


Figure 4.6 True volumetric strain versus mean normal stress

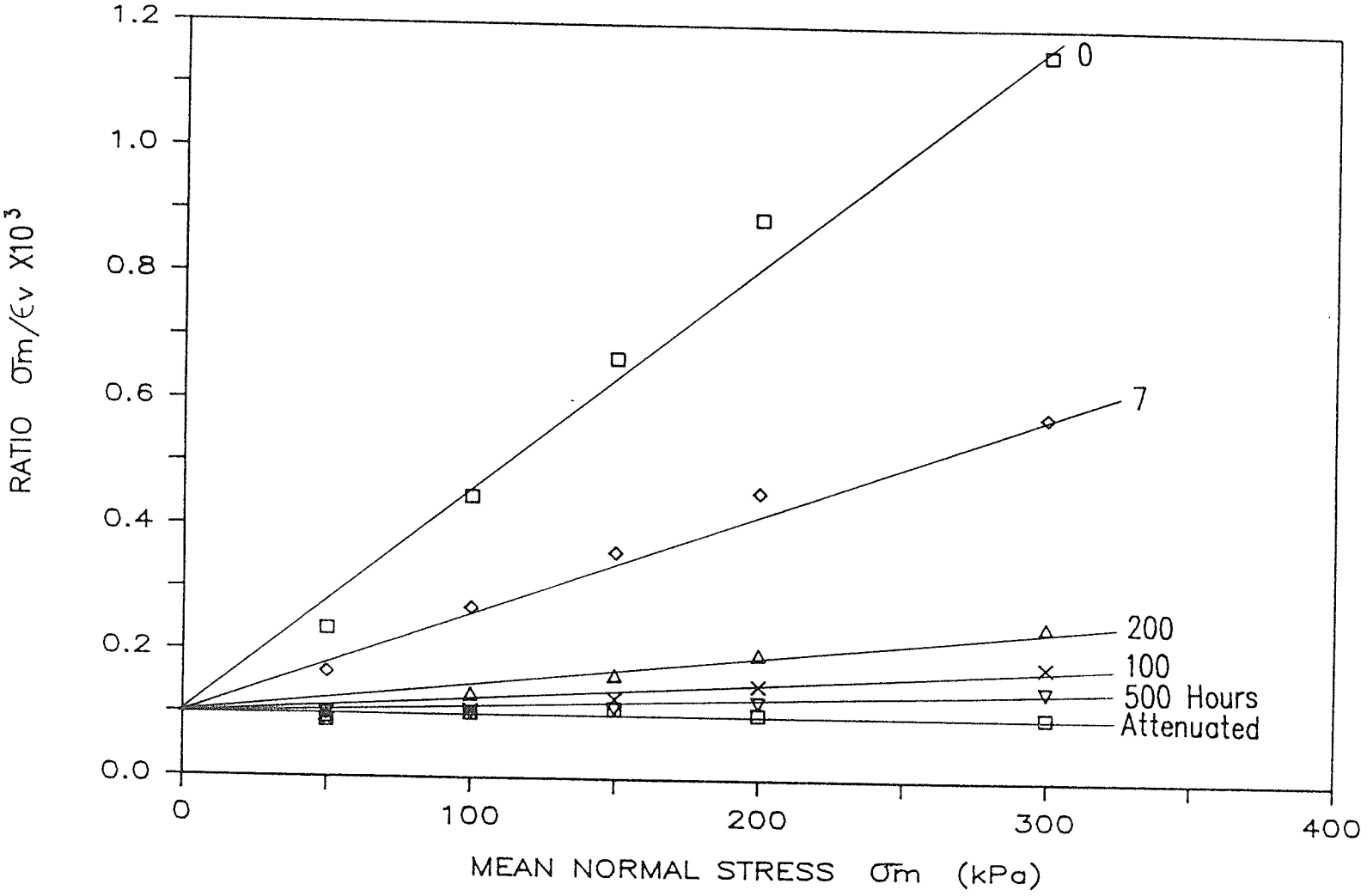


Figure 4.7 Ratio $\sigma m/\epsilon_v$ versus mean normal stress

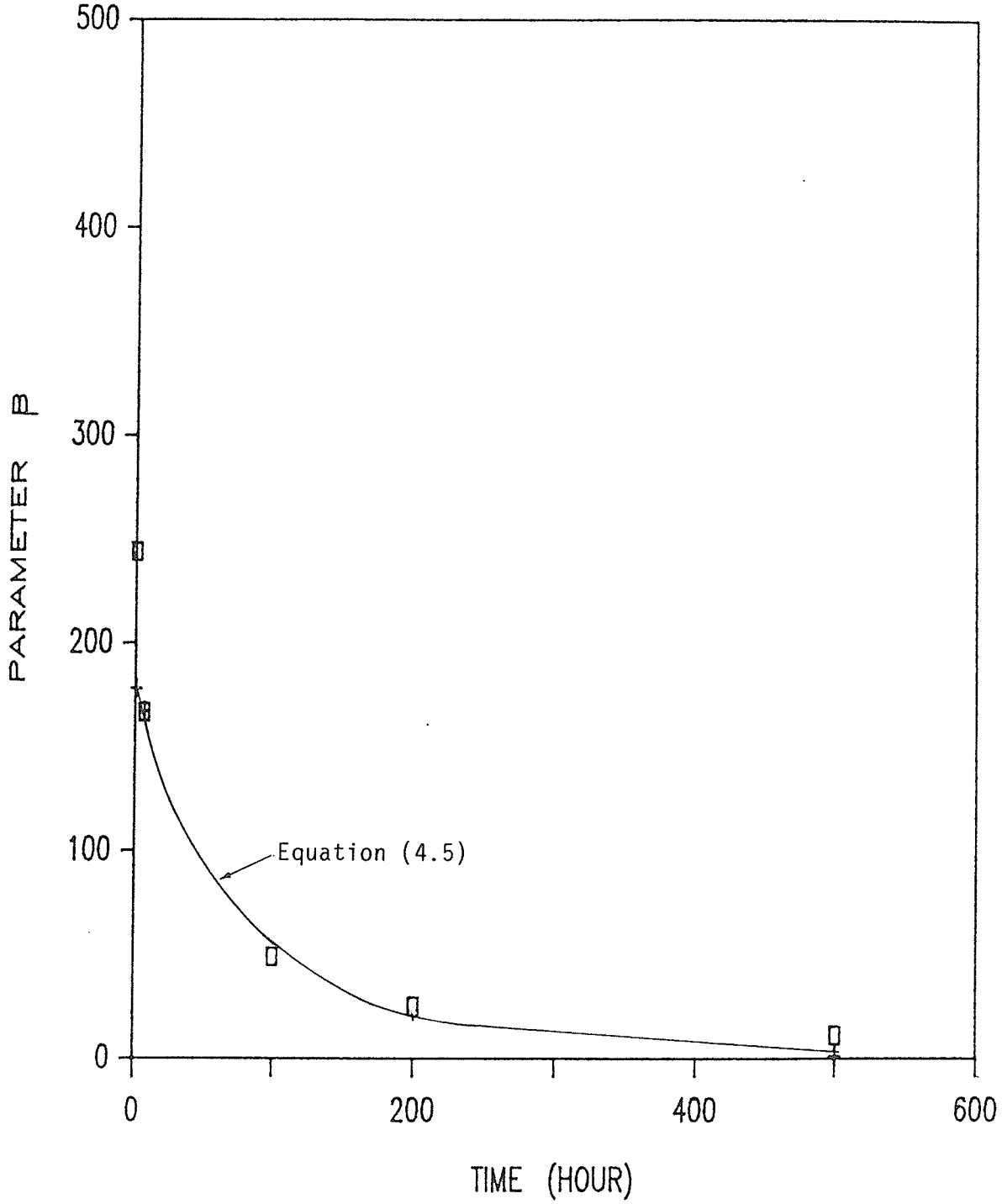


Figure 4.8 Parameter β versus time

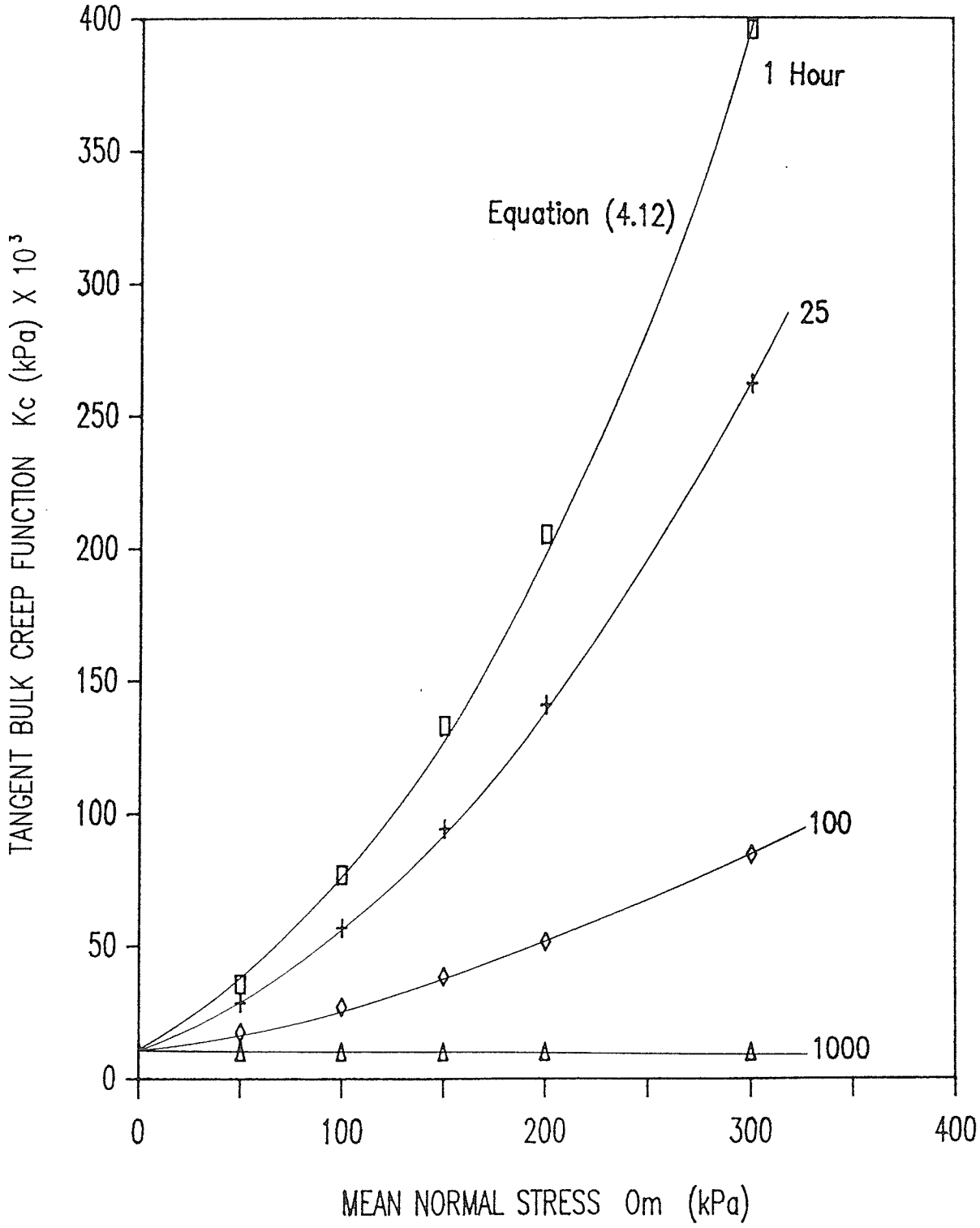


Figure 4.9 Bulk creep function versus mean normal stress

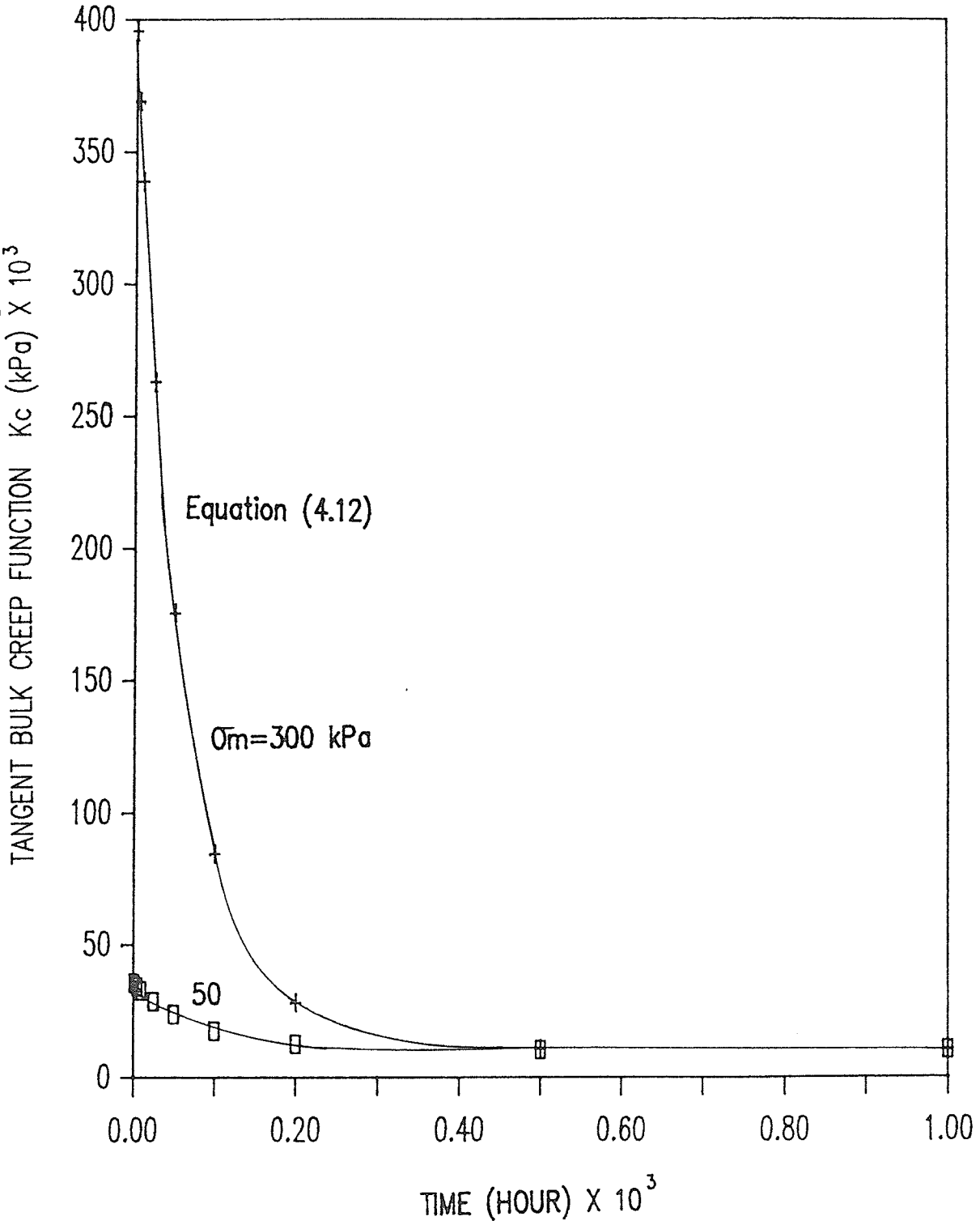


Figure 4.10 Bulk creep function versus time

CHAPTER FIVE
SHEAR CREEP FUNCTION

CHAPTER 5

SHEAR CREEP FUNCTION

5.1 INTRODUCTION

The shear creep function, G_c, as defined by equation 2.48, relates the resultant shear stress and the associated resultant creep shear strain. Since the relationship is nonlinear, the shear creep function is defined as the instantaneous slope of the resultant shear stress-strain curve and is represented by:

$$\frac{dS_d}{d\varepsilon_d} = G_c = \lim_{\Delta S_d \to 0} \left(\frac{\Delta S_d}{\Delta \varepsilon_d}\right) \tag{5.1}$$

For frozen soil the shear creep function depends on a number of factors, such as, mean normal stress, resultant deviatoric stress, time, temperature and material properties which include mineralogy, grain size, ice content, unfrozen water content, gases and air voids. The shear creep function may be determined by pure shear, torsion or constant mean normal stress triaxial compression tests. In the present investigation constant mean normal stress triaxial compression tests were used to evaluate the shear creep function of a quartz carbonate sand. The investigation included the influence of mean normal stress, resultant deviatoric stress, and duration of loading on the shear creep function.

Very few studies have been carried out to evaluate the shear modulus of frozen soils, but extensive studies have been made in the determination of the dynamic shear modulus and cyclic stress-strain characteristics of unfrozen soils. Constant mean normal stress triaxial compression tests have been succesfully used for the evaluation of static shear modulus of unfrozen soils by Valliappan (1974), Liu (1970), Domaschuk (1969), and Gill (1969).

The development of an expression for the shear creep function including the test procedure for constant mean normal stress triaxial tests is presented in this chapter.

5.2 TEST PROCEDURE

5.2.1 Constant Mean Normal Stress Multi-stage Triaxial Tests

The constant mean normal stress multi-stage triaxial tests were conducted to determine the relationship between shear stress and strain. After the sample was set up as outlined in Chapter 3, a 24-hour period was allowed before load application to bring the sample and the system into temperature equilibrium. The physical properties of the frozen sand samples are given in Table 5.1. The cell pressure was applied by bottled nitrogen gas and the pressure was monitored by a pressure transducer and double checked by a pressure gauge mounted on the high precision two-stage regulator. A constant axial stress was applied to the sample through a hanger and lever arm system.

As in the multi-stage isotropic test, the cell was hooked up with a temperature controlled bath maintained at -3°C. A thermistor mounted on the inner cell measured the temperature of the cell fluid. The axial deformation of the sample was monitored by means of a displacement transducer (LVDT) mounted on the load piston of the cell. The volume change of the sample was measured by measuring the change in volume of the fluid in the inner cell using a burette.

Each test was carried out at a pre-chosen mean normal stress using a stepwise increase in deviatoric stress. Firstly the sample was isotropically consolidated under the pre-chosen mean normal stress. Volume changes and axial deformations were recorded with time. The deviatoric stress was then applied by appropriately decreasing the confining pressure and increasing the axial stress so as to maintain the mean normal stress constant. The decrement of confining pressure, increment of axial stress and the resultant deviatoric stresses are given in Table 5.2. Each deviatoric stress level was maintained until the axial strain remained essentially constant for about two days or until the axial strain rate became less than 2×10^{-5} percent per hour which was chosen arbitrarily. After this, a new stress step was applied and generally this procedure of increasing the deviatoric stress was repeated until the sample failed or the cell pressure was lowered to 0 kPa. Axial deformations, volume changes and thermistor readings were recorded at frequent time intervals.

In order to maintain a constant mean normal stress, it was

necessary to know the cross-sectional area of the sample at all stages of the test. In this respect the cross-sectional area was calculated on the assumption that the sample retained its cylindrical shape throughout the test. The axial load adjustments were made at the start of each stress step and also during the stress step when the deformation, and hence the change in area, was significant. Each of the multi-stage tests is dealt with in sections 5.3.1 through 5.3.5.

5.3 TEST RESULTS

The volumetric and axial deformations were converted to true volumetric and true axial strains respectively. True volumetric strain was defined in Section 4.3.1. The true axial strain differs from conventional engineering strain in that each increment of strain is based on the actual length at the time of the increment instead of the original length. The true axial strain is given by :

$$\varepsilon = \int_{L_o}^{L_t} \frac{dL}{L} = \ln \frac{L_t}{L_o} \qquad (5.2)$$

in which dL = change in length

L_t = length of the sample at time t

L_o = length of the sample at time, t=0

5.3.1 MST1

In this test the mean normal stress was 140 kPa and the increment of resultant deviatoric stress component, S_d, was 49 kPa. Seven stepwise increments of deviatoric stress were applied. Details of the stress applications are given in Table 5.3 and the axial and volumetric deformations are given in the Appendix.

The cumulative true axial and true volumetric strains versus time for the entire test are shown in Figure 5.1 and for each individual stress application in Figure 5.2. The sample underwent attenuating axial creep when subjected to resultant deviatoric stress steps of 49, 98, 147, 196 kPa. Inadvertently the stress step of S_d=245 kPa was not maintained long enough to positively identify the creep rate as attenuating or accelerating. The first definite indication of axial accelerating creep occurred during the stress step, S_d= 294 kPa, at time t=750 hours. This stress was maintained for a total of 1154 hours and then the next stress step, S_d=343 kPa, was applied. The axial creep rate continued to accelerate under the added stress. The rate of axial creep increased substantially.

The volumetric strains indicated that the sample continued to decrease in volume until the stress step reached S_d=245 kPa, and remained essentially unchanged at this stress level and then increased in volume when the stress level was increased to S_d=294 kPa. The onset of dilation corresponded with the stress level at which accelerating axial creep first occurred.

5.3.2 MST2

In this test the mean normal stress was 280 kPa and the increment of resultant deviatoric stress was 98 kPa. Five stepwise increments of deviatoric stress were applied. Details of the stress applications are given in Table 5.4 and the axial and volumetric deformations are given in the Appendix.

The cumulative true axial and true volumetric strains versus time for the entire test are shown in Figure 5.3 and for each individual stress application in Figure 5.4. The sample underwent attenuating axial creep up to a stress level of S_d=392 kPa, accelerating creep occurred at the next stress step of S_d=490 kPa, and the test was terminated at this stress level. The volumetric strain indicated that dilatancy also first occurred at S_d=490 kPa. During the stress level of S_d=294 kPa, there was a breakdown in the cold room refrigeration unit and the sample temperature rose to -1°C. This resulted in a sharp increase in both the axial and volumetric strains. When the sample temperature was restored to -3°C, the axial and volumetric strains continued at rates comparable to those that preceded the breakdown.

5.3.3 MST3

For this test the mean normal stress was 280 kPa which was same as in the test MST2, but the increment of resultant deviatoric stress,

S_d, was doubled to 196 kPa to see whether or not the magnitude of the deviatoric stress step had any influence on the results. Two stepwise increments of deviatoric stress were applied. Details of the stress applications are given in Table 5.5 and the axial and volumetric deformations are given in the Appendix. This test was conducted simultaneously with Test, MST2, and was therefore subjected to the same cold room temperature variations associated with the breakdown of the refrigeration unit.

The cumulative true axial and true volumetric strains versus time for the entire test are shown in Figure 5.5 and for each individual stress step in Figure 5.6. The sample underwent attenuating creep during the first increment of S_d=196 kPa. The accelerating creep first occurred during the second increment at a stress level of S_d=392 kPa and the test was terminated at this stress level. The volumetric strain data indicated that the dilatancy first occurred at the same stress level, S_d=392 kPa. It was observed from a comparison of tests MST2 and MST3 that the increase in S_d from 98 kPa to 196 kPa reduced the stress level at which accelerating axial creep and dilation first occurred from 490 kPa to 392 kPa. This appears to be reasonable because the higher stress increment caused a higher axial strain rate and the sample did not get enough time to adjust to the new stress level.

5.3.4 MST4

In this test the mean normal stress was 70 kPa and the incremental resultant deviatoric stress was 49 kPa. Three stepwise increments of deviatoric stress were applied. Details of the stress applications are given in Table 5.6 and the axial and volumetric deformations are given in the Appendix.

The cumulative true axial and true volumetric strains were plotted against time for the entire test in Figure 5.7 and for each individual stress application in Figure 5.8. The sample underwent attenuating creep under stress levels of S_d=49 and 98 ka, and accelerating creep occurred at a stress level of 147 kPa. The volumetric strain data indicated that dilatancy also first occurred at S_d=147 kPa and the test was terminated at this stress level.

5.3.5 MST5

In this test the mean normal stress was 420 kPa and the incremental resultant deviatoric stress, S_d, was 196 kPa. Three stepwise increments of deviatoric stress were applied. Details of the stress applications are given in Table 5.7 and the axial and volumetric deformations are given in the Appendix.

The cumulative true axial and true volumetric strains versus time for the entire test are shown in Figure 5.9 and for each individual stress application in Figure 5.10. The sample underwent attenuating axial creep up to the stress level of S_d=392 kPa and

accelerating axial creep occurred at the next stress step of S_d=588 kPa. The volumetric strain data indicated that dilatancy also first occurred at the same stress level of S_d=588 kPa. The test was terminated at this stress level.

5.4 CREEP RATES

5.4.1 Introduction

The axial creep rate of a frozen soil depends on the deviatoric stress in a constant stress test. The strain rate versus time curves for various stress levels in unconfined compression tests for the Ottawa sand as reported by Rein et al. (1975) are presented in Figure 5.11 and those for a frozen silt as reported by Yalin (1984) are presented in Figure 5.12. It was observed that the strain rates in all the plots reached a minimum and thereafter increased.

The strain rate versus time curves for polycrystalline ice as reported by Mellor and Cole (1982) are presented in Figure 5.13. The nature of the plots were the same as those of the sand and the silt presented by Rein et al. (1975), and Yalin and Carbee (1984) respectively in that the strain rate passed through a minimum.

It is observed that the stress in each case was high enough so that the strain rate passed through a minimum and the researchers were only interested in finding the time to reach the minimum strain rate.

5.4.2 Axial Creep Rates

Axial creep rates versus time for the tests presented in Section 5.3 are shown plotted in Figures 5.14 through 5.18 for the individual tests. The mean normal stress and the deviatoric stress for each test are indicated in the figures. Smooth curves were drawn through the data points. It was observed that in most instances the creep rate tended to decrease towards zero and only in three instances did the creep rate pass through a minimum and then accelerate. In these three instances the ratio of the resultant deviatoric stress to the mean normal stress ranged from 1.75 to 2.1. However there were two tests in which the aforementioned stress ratios were 2.1 and 1.4 and the creep rate continued to decrease with time within the test time period.

To investigate the effects of resultant deviatoric stresses on the axial creep rate, the axial creep rate versus time curves having the same mean normal stress but different resultant deviatoric stresses were superimposed on single plots as shown in Figures 5.19 through 5.23. It was observed in all the figures that for a constant mean normal stress, the higher the resultant deviatoric stresses the higher the creep rate at any given time.

To determine the effects of the mean normal stress on creep rates, tests conducted at the same deviatoric stress and with the same

increment of deviatoric stress but at different mean normal stresses were selected. Tests MST3 and MST5, with resultant deviatoric stress, S_d=196 kPa, increment of resultant deviatoric stress, S_d=196 kPa, and constant mean normal stresses, σ_m=280 and 420 kPa respectively, were selected. The creep rate versus time relationship for these two tests are shown in Figures 5.24 and 5.25. It is observed in Figure 5.24 that for attenuating creep there was no significant difference in creep rates for a difference in mean normal stresses of 140 kPa. For resultant deviatoric stress, S_d=392 kPa, as observed in Figure 5.25 the creep rate passed through a minimum and then accelerated for σ_m=280 kPa whereas the creep rate tended to become zero for σ_m=420 kPa. This suggests that the strength increased with an increase in the mean normal stress.

5.4.3 Time to Attenuation

It is observed in Figures 5.19 through 5.23 that the mean normal stress had some influence on the time to complete attenuation. Tests MST3 and MST5, conducted at the same resultant deviatoric stress of 196 kPa with the same increment of resultant deviatoric stress, S_d=196 kPa, but at different mean normal stresses of 280 and 420 kPa respectively, were selected to determine the effects of mean normal stress on time to complete attenuation. Time to complete attenuation, for the resultant deviatoric stress of 196 kPa, versus mean normal stress were shown plotted in Figure 5.26. It was observed that the time to complete attenuation increased exponentially with an increase in the mean normal stress.

5.5 FAILURE CRITERION

5.5.1 Failure Stress

It was observed from the Figure 5.1 through 5.10 that during shear deformation the samples initially underwent volume reduction and then dilation. It can be assumed that the beginning of dilation coincided with the initiation of cracks in the sample and any further increase in stress would cause the cracks to continue to grow with time. Generally the beginning of dilation coincided with acceleration of the axial creep rate, which supports the concept of fracture development.

A plot of resultant deviatoric stress at which dilation first occurred, versus mean normal stress, is shown in Figure 5.27 and the values are presented in tabular form in Table 5.8. The relationship in

TABLE 5.8

Resultant deviatoric stress at failure and mean normal stress

Test	σ_m (kPa)	Sd_f (kPa)
MST1	140	294
MST2	280	392
MST3	280	490
MST4	70	147
MST5	420	588

fact can serve as a failure criterion in which failure is defined as

the onset of tertiary creep. For the tests conducted the relationship was found to be linear and can be expressed as:

$$S_{df} = S_{do} + m\sigma_m \qquad (5.3)$$

in which Sd_o is the intercept corresponding to σ_m=0, and the parameter, m, is the rate at which the failure resultant deviatoric stress, S_{df}, increases with the mean normal stress. For the given soil,temperature, and stress range, Sd_o=100 kPa and m=1.3 and equation (5.3) becomes:

$$Sd_f = 100 + 1.3\ \sigma_m \quad (kPa) \qquad (5.4)$$

From equation (5.4) it is obvious that the mean normal stress has a very profound effect on failure stress as defined herein. An increase in strength of frozen sand with an increase in confining pressure was observed by Sayles (1973), Chamberlain et al (1972), Alkire and Andersland (1973), Smith and Cheatham (1975), Parameswaran and Jones (1981), and Jones and Parameswaran (1983).

The concept of a threshold stress that defines the onset of accelerating creep was supported by Man (1984) in his theoretical formulation to determine long term strength of frozen soils. Man stated that for viscoelastic material, there is always a stress, at a particular temperature, below which the material behaves as a solid and exhibits attenuating creep and above which, the material behaves as a fluid and undergoes stationary creep.

5.5.2 Failure Strain

The creep failure strain has been expressed in the literature as a function of minimum creep strain rate, $\dot{\varepsilon}_m$, and time to reach minimum creep strain rate, t_m, (Ting, 1983 ; Yalin and Carbee, 1984) and the form of the equation was as follows :

$$\varepsilon_f = \dot{\varepsilon}_m \, t_m^n \qquad (5.5)$$

To satisfy the above relationship the sample must pass through a minimum strain rate in a constant stress creep test which means that the applied stress must be large enough to produce tertiary creep. In the studies mentioned above, the applied stresses were of sufficient magnitude to produce tertiary creep. In defining the minimum strain rate and the time to reach the minimum strain rate, Ting (1983) suggested the existence of an approximately constant strain at the minimum strain rate. Mellor and Cole (1982) plotted strain rate against axial strain for polycrystalline ice and found that the minimum strain rate occurred at about 1 percent of axial strain. This implies that the failure phenomenon is strain dependent rather than stress dependent. In the writer's investigation it was found that the total axial strain at failure, i.e the start of dilation varied with the stress and ranged between 1 and 2 percent. Figure 5.28 shows the axial strain at failure plotted against the mean normal stress. The axial strains at failure increased with an increase in mean normal stress. This can be explained by noting that ductile fractures generally occur

by the formation and subsequent growth of and coalescence of voids and cavities. If the cavity nucleation can be delayed or suppressed by increasing the mean normal stress, an increase in strength can be achieved. In the case of frozen sand an increase in mean normal stress may have had the effect of delaying (from the point of view of strain) the development and growth of fractures.

5.6 SHEAR CREEP FUNCTION

5.6.1 Resultant Deviatoric Stress-Strain Curve

The resultant deviatoric stress as defined by equation (2.42) reduces to the following form for the case of triaxial compression tests.

$$S_d = \sqrt{\frac{2}{3}}(\sigma_1 - \sigma_3) \qquad (5.6)$$

in which $\sigma_2 = \sigma_3$ and

$$\sigma_m = \frac{\sigma_1 + 2\sigma_3}{3}$$

As well the resultant deviatoric strain as defined by equation (2.44) reduces to the following form :

$$\varepsilon_d = \frac{2\sqrt{2}}{\sqrt{3}} (\varepsilon_1 - \varepsilon_3) \qquad (5.7)$$

in which $\varepsilon_2 = \varepsilon_3$

$$\varepsilon_m = \frac{\varepsilon_1 + 2\varepsilon_3}{3}$$

In the evaluation of resultant deviatoric strain, the axial strain, ε_1, was measured during the experimental investigation and the lateral strain ε_3, was calculated from the measured sample volume change and axial strain assuming that the sample remained cylindrical during deformation. For small strains it may be assumed that

$$\varepsilon_v = \varepsilon_1 + \varepsilon_2 + \varepsilon_3 \qquad (5.8)$$

or $$\varepsilon_v = \varepsilon_1 + 2\varepsilon_3 \qquad (5.9)$$

The resultant deviatoric strain versus time curves for various resultant deviatoric stresses and mean normal stresses are presented in Figures 5.29 through 5.33. From these data, resultant deviatoric stress versus resultant deviatoric strain after various elapsed times were plotted and are shown in Figures 5.34 through 5.38. The total resultant deviatoric strain at any particular time was assumed to be the sum of all the instantaneous strains and the creep strains which the sample had undergone prior to the time under consideration. Figures 5.34 through 5.38 indicated that the deviatoric stress-strain relationship for the chosen time were nonlinear. The curves for t=500 hours, were of hyperbolic form while all others were of a power form.

5.6.2 Shear Creep Function

As defined earlier, the shear creep function is the instantaneous slope of the resultant deviatoric stress-strain curve, at a given time. The instantaneous slope of the stress-strain curve was determined graphically at selected points and plotted against the ratio of mean normal stress to the resultant deviatoric stress in Figures 5.39 through 5.42. The curves can be represented by the following hyperbolic equation:

$$G_c = \frac{\sigma_m/S_d}{a + b\,(\sigma_m/S_d)} \qquad (5.10)$$

in which G_c = shear creep function

σ_m = mean normal stress

S_d = resultant deviatoric stress

a & b= constants

The equation (5.10) can be rearranged in the following form:

$$\frac{\sigma_m/S_d}{G_c} = a + b\,\frac{\sigma_m}{S_d} \qquad (5.11)$$

The hyperbolic curves defined by equation (5.10) linearized in the transformed plot, $(\sigma_m/S_d)/G_c$ versus (σ_m/S_d), as shown in Figures 5.43 through 5.46.

The parameter, a, which varied with time was found to linearize on a log-log scale as shown in Figure 5.47. The scatter of the points due to various mean normal stress was so small that the relationship could be represented by a single straight line with the following equation:

$$a = ct^{\alpha} \tag{5.12}$$

in which c = value of 'a' at an arbitrarily chosen time t=1 hour

t = time

α = slope of the straight line

The parameter, b, is shown plotted against time on a log-log scale in Figure 5.48. The straight lines obtained was represented by the following equation:

$$b = mt^{n} \tag{5.13}$$

in which n = slope of the straight lines

t = time

m = value of 'b' at time t=1 hour

It was observed that the slope, n, was independent of the mean normal stress whereas the factor m was dependent on the mean normal stress. The values of m were plotted against the mean normal stresses on a log-log scale in Figure 5.49 and the straight line obtained was

represented by the following equation:

$$m = m_1 \, \sigma_m^{\beta} \tag{5.14}$$

in which m_1 = value of m at σ_m=1 kPa

β = slope of the straight line

σ_m = mean normal stress

Substituting equation (5.14) in equation (5.13), the parameter b, can be represented by the following equation:

$$b = m_1 \, \sigma_m^{\beta} \, t^n \tag{5.15}$$

Substituting equation (5.12) for 'a'and equation (5.15) for 'b' in equation (5.10), the equation for the shear creep function can be written as:

$$G_c = \left(m_1 \, \sigma_m^{\beta} \, t^n + ct^{\alpha} \frac{S_d}{\sigma_m} \right)^{-1} \tag{5.16}$$

which for the tests conducted becomes:

$$G_c = \left(3\text{x}10^{-5} \, \sigma_m^{-0.205} \, t^{0.147} + 1\text{x}10^{-5} \, t^{0.23} \frac{S_d}{\sigma_m} \right)^{-1} \tag{5.17}$$

According to equation (5.17), the shear creep function, G_c, decreases exponentially with an increase in time after the load application. This is illustrated by plots of G_c versus time in Figures

5.50 through 5.53 for various deviatoric stresses and for various mean normal stresses, in which the values predicted by the equation are represented by the solid lines and the data points by the symbols. The shear creep function, G_c, increases hyperbolically with an increase in mean normal stress. This is shown by plots of G_c versus mean normal stress for various times in Figure 5.54. On the other hand, as shown in Figure 5.55, the shear creep function decreases exponentially with an increase in deviatoric stress for a constant time.

TABLE 5.1

Physical Properties of Frozen Sand Sample

Sample	Dry Unit Weight KN/m^3	Water Content %	Porosity %	Water Saturation %	Sample Test Temp. ^oC
MST1	15.2	26.6	43.2	92.5	-3
MST2	15.2	25.3	43.6	88.5	-3
MST3	15.6	24.4	41.1	94.5	-3
MST4	15.7	25.0	41.7	94.1	-3
MST5	15.8	24.1	40.6	90.0	-3

TABLE 5.2

Summary of Stress Conditions for the Constant Mean Normal Stress Tests

Test	σ_m (kPa)	σ_3 (kPa)	σ_1 (kPa)	S_d (kPa)
MST1	140	-20	+40	49.0
MST2	280	-40	+80	98.0
MST3	280	-80	+160	196.0
MST4	70	-20	+40	49.0
MST5	420	-80	+160	196.0

TABLE 5.3

Details of Stress Application

test MST1 σ_m=140 kPa

σ_1 (kPa)	σ_3 (kPa)	S_d (kPa)	Duration of Stress Application (Hours)
140	140	0	21
180	120	49	3
220	100	98	69
260	80	147	95
300	60	196	94
340	40	245	95
380	20	294	1154
420	0	343	862

TABLE 5.4

Details of Stress Application

Test MST2 σ_m=280 kPa

σ_1 (kPa)	σ_3 (kPa)	S_d (kPa)	Duration of Stress Application (Hour)
280	280	0	596
360	240	98	475
440	200	196	504
520	160	294	1006
600	120	392	1393
680	80	490	984

TABLE 5.5

Details of Stress Application

Test MST3 σ_m=280 kPa

σ_1 (kPa)	σ_3 (kPa)	S_d (kPa)	Duration of Stress Application (Hour)
280	280	0	570
440	200	196	410
600	120	392	1848

TABLE 5.6

Details of Stress Application

Test MST4 σ_m=70 kPa

σ_1 (kPa)	σ_3 (kPa)	S_d (kPa)	Duration of Stress Application (Hour)
70	70	0	960
110	50	49	815
150	30	98	1852
190	10	147	1808

TABLE 5.7

Details of Stress Application

Test MST5 σ_m=420 kPa

σ_1 (kPa)	σ_3 (kPa)	S_d (kPa)	Duration of Stress Application (Hour)
420	420	0	1152
580	340	196	817
740	260	392	1029
900	180	588	2144

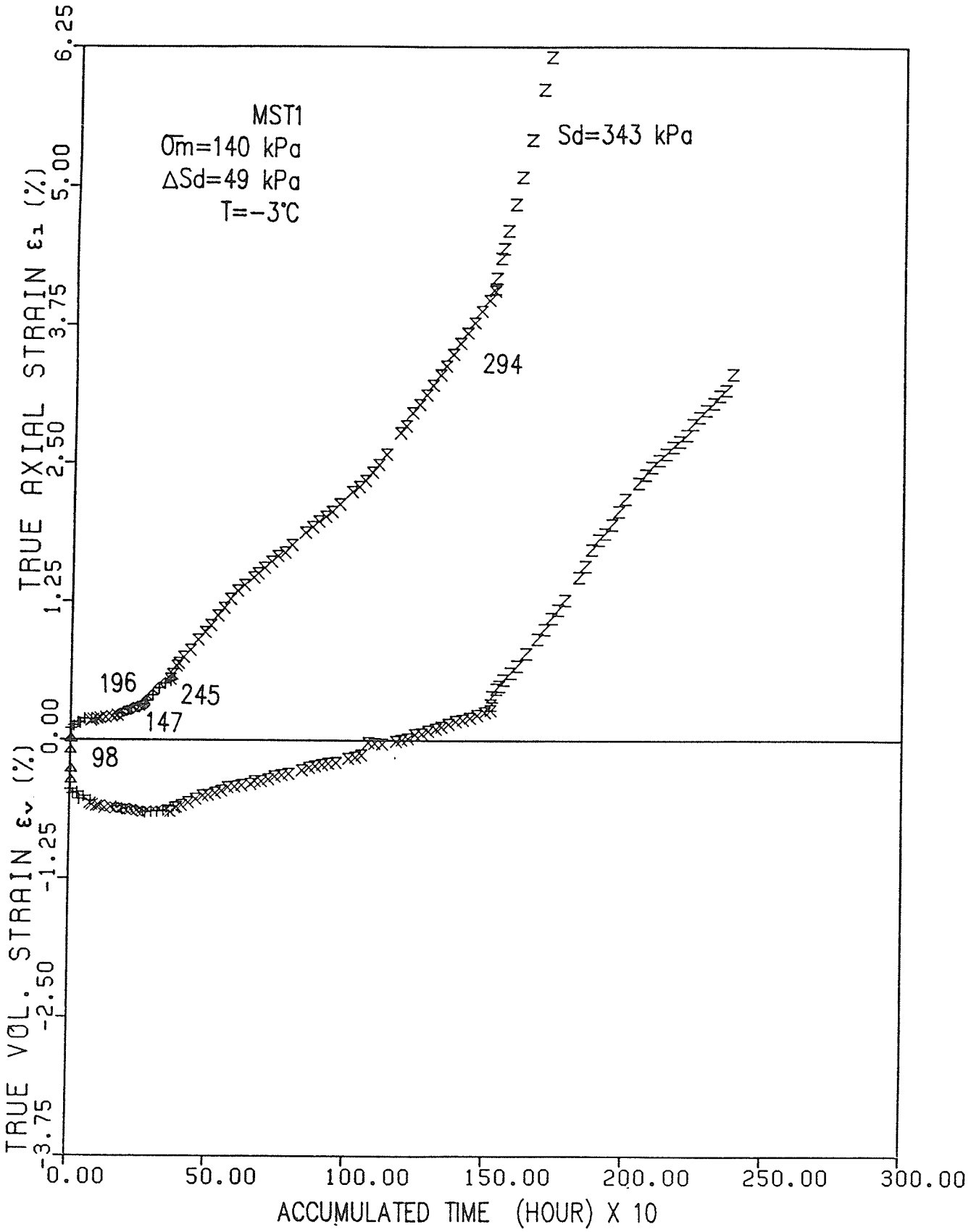


Figure 5.1 True volumetric and true axial strain versus accumulated time (MST1)

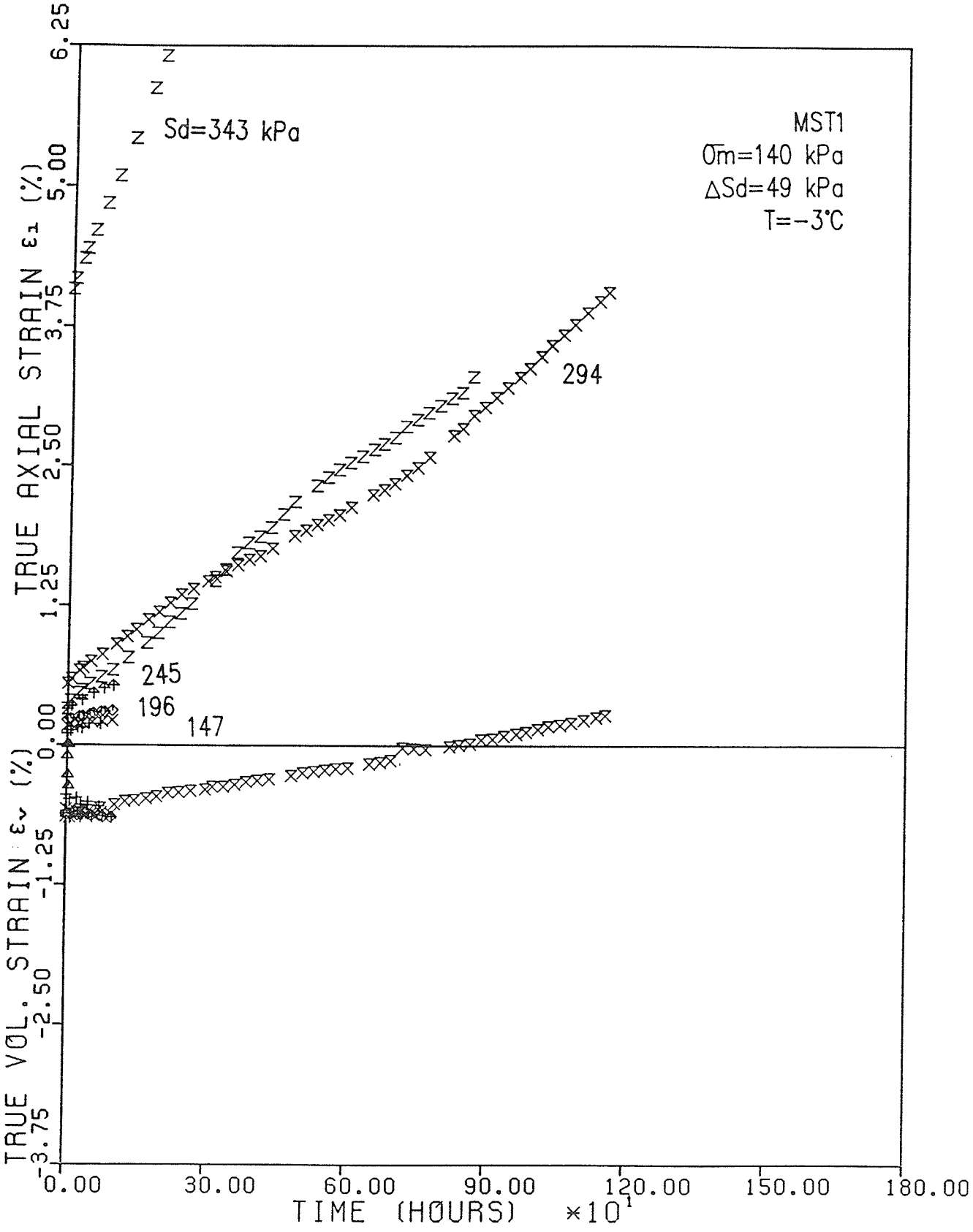


Figure 5.2 True volumetric and true axial strain versus time (MST1)

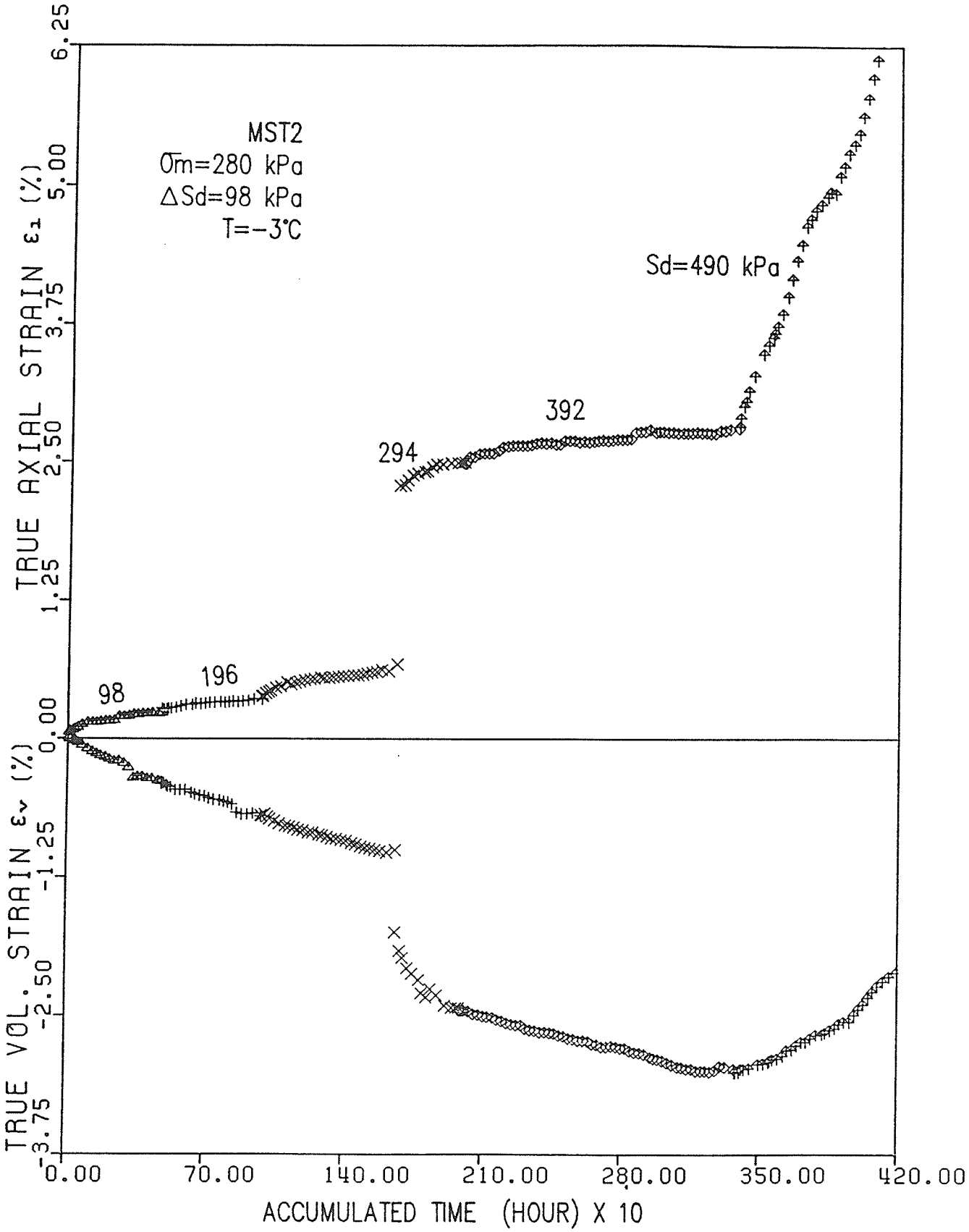


Figure 5.3 True volumetric and true axial strain versus accumulated time (MST2)

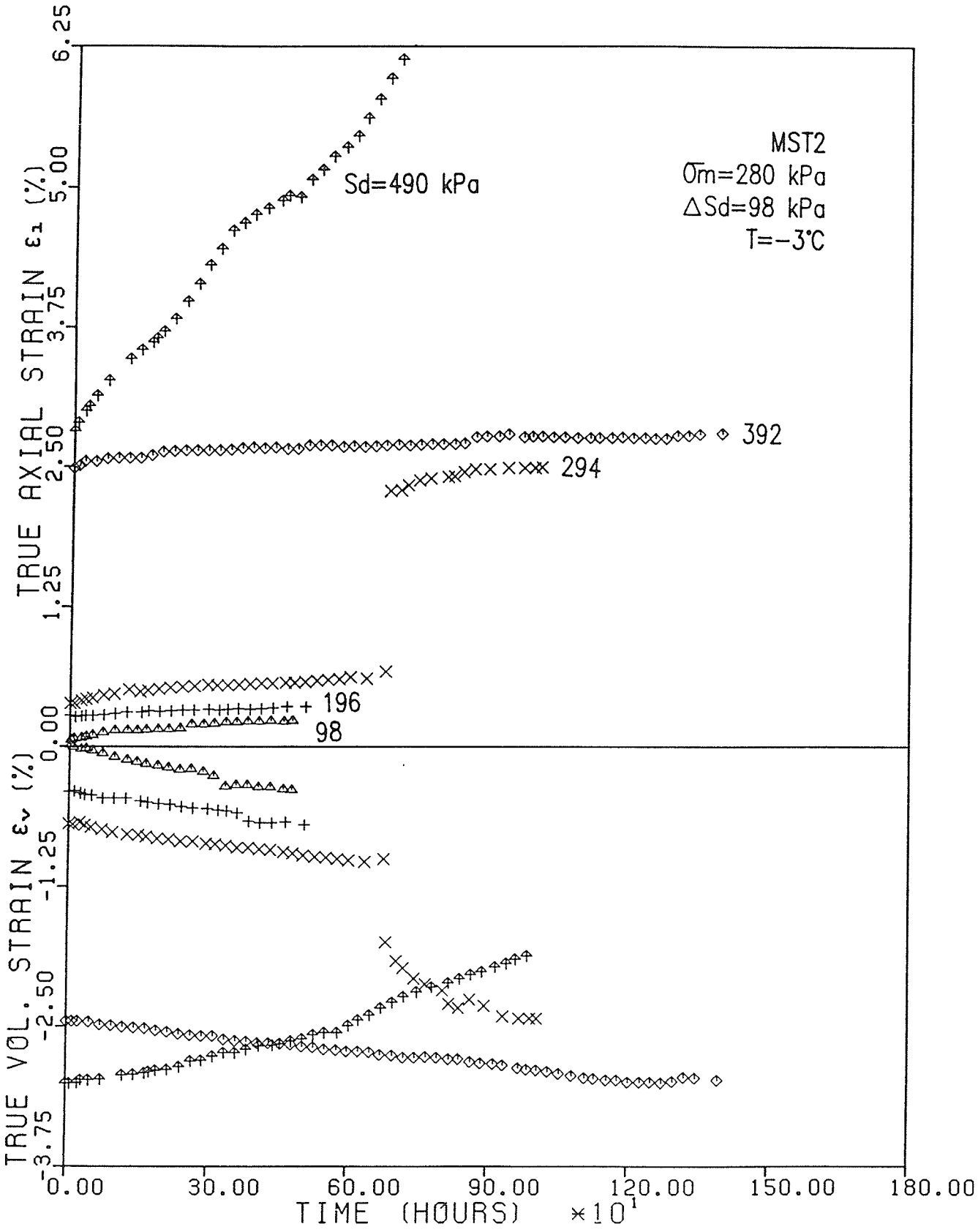


Figure 5.4 True volumetric and true axial strain versus time (MST2)

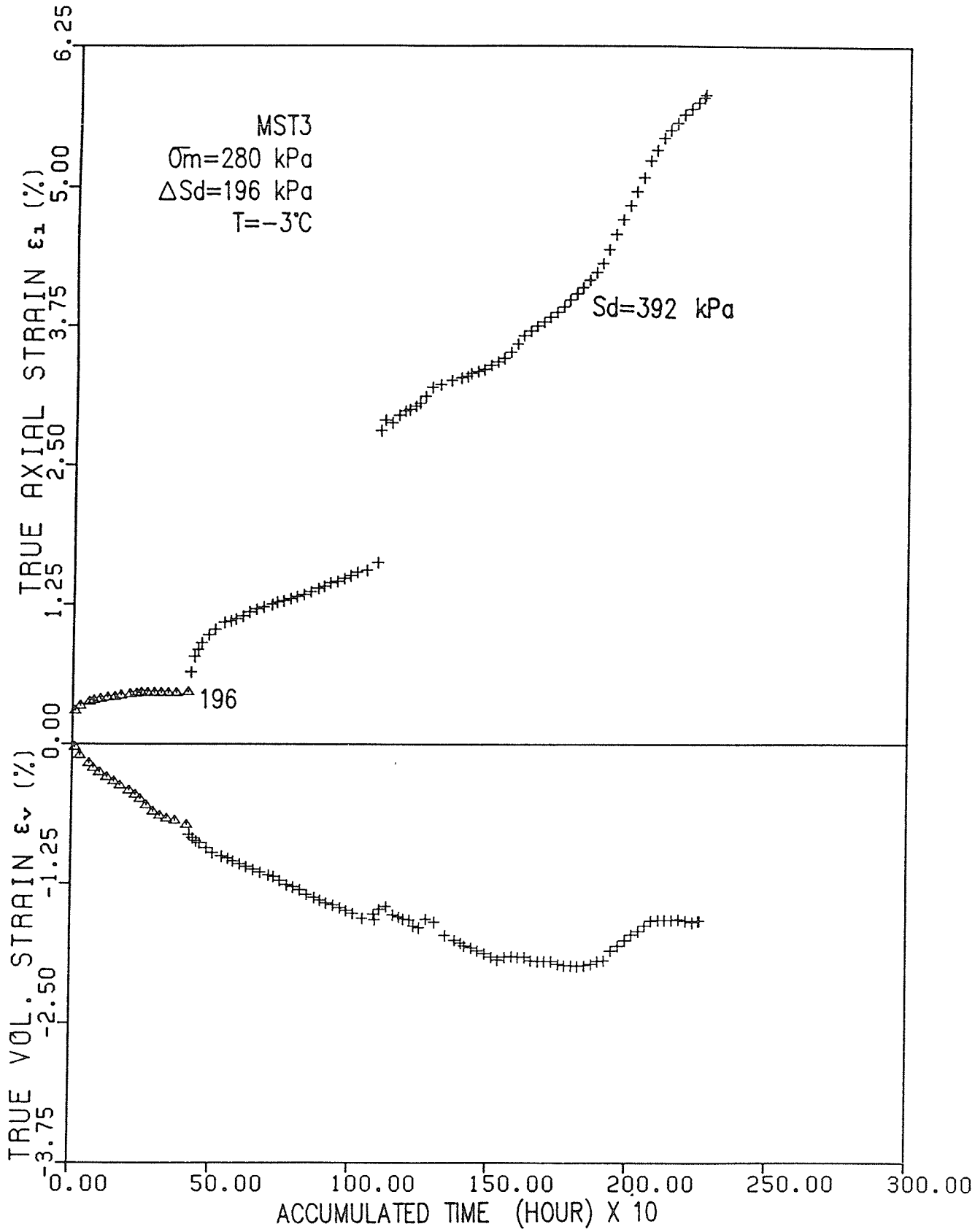


Figure 5.5 True volumetric and true axial strain versus accumulated time (MST3)

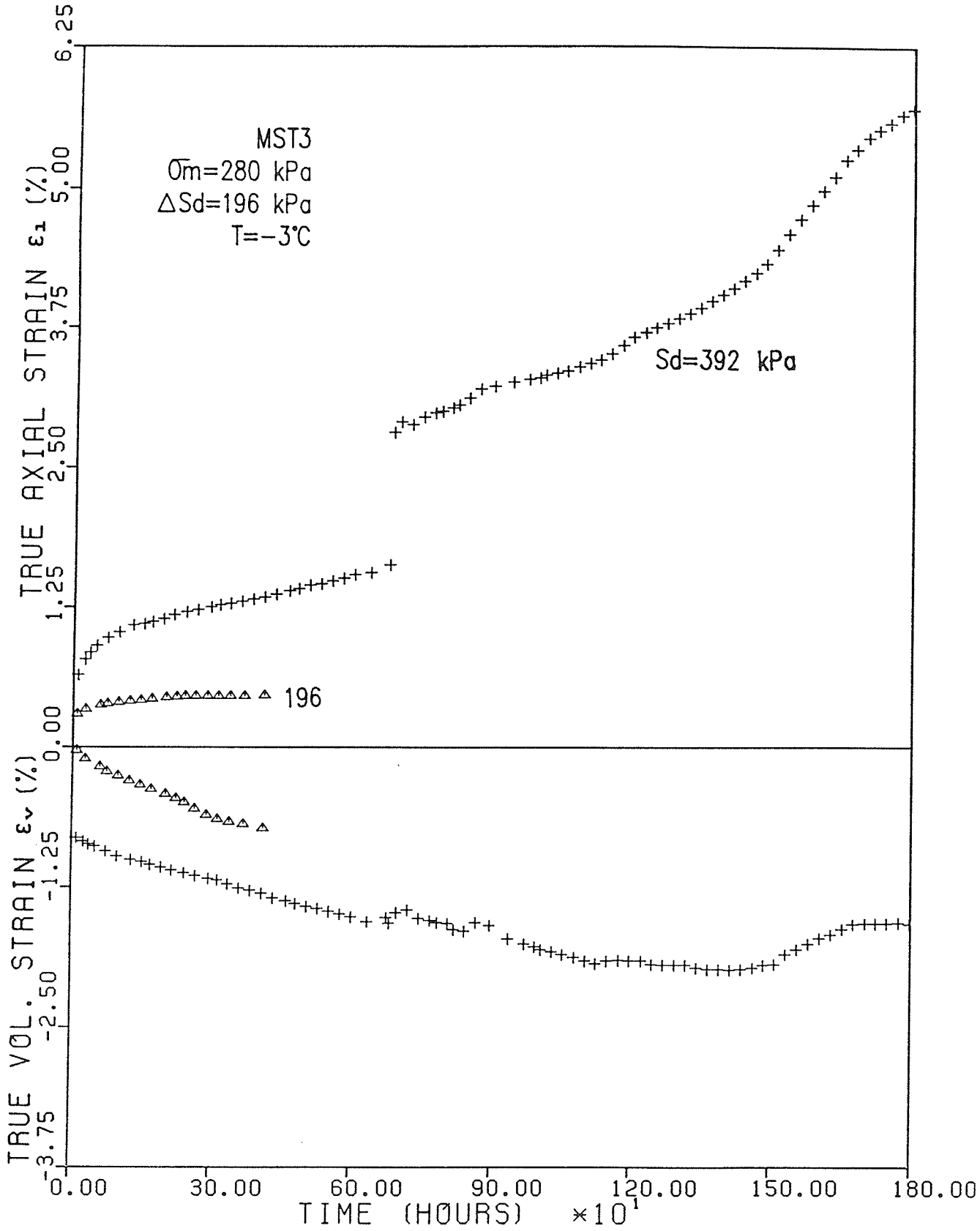


Figure 5.6 True volumetric and true axial strain versus time (MST3)

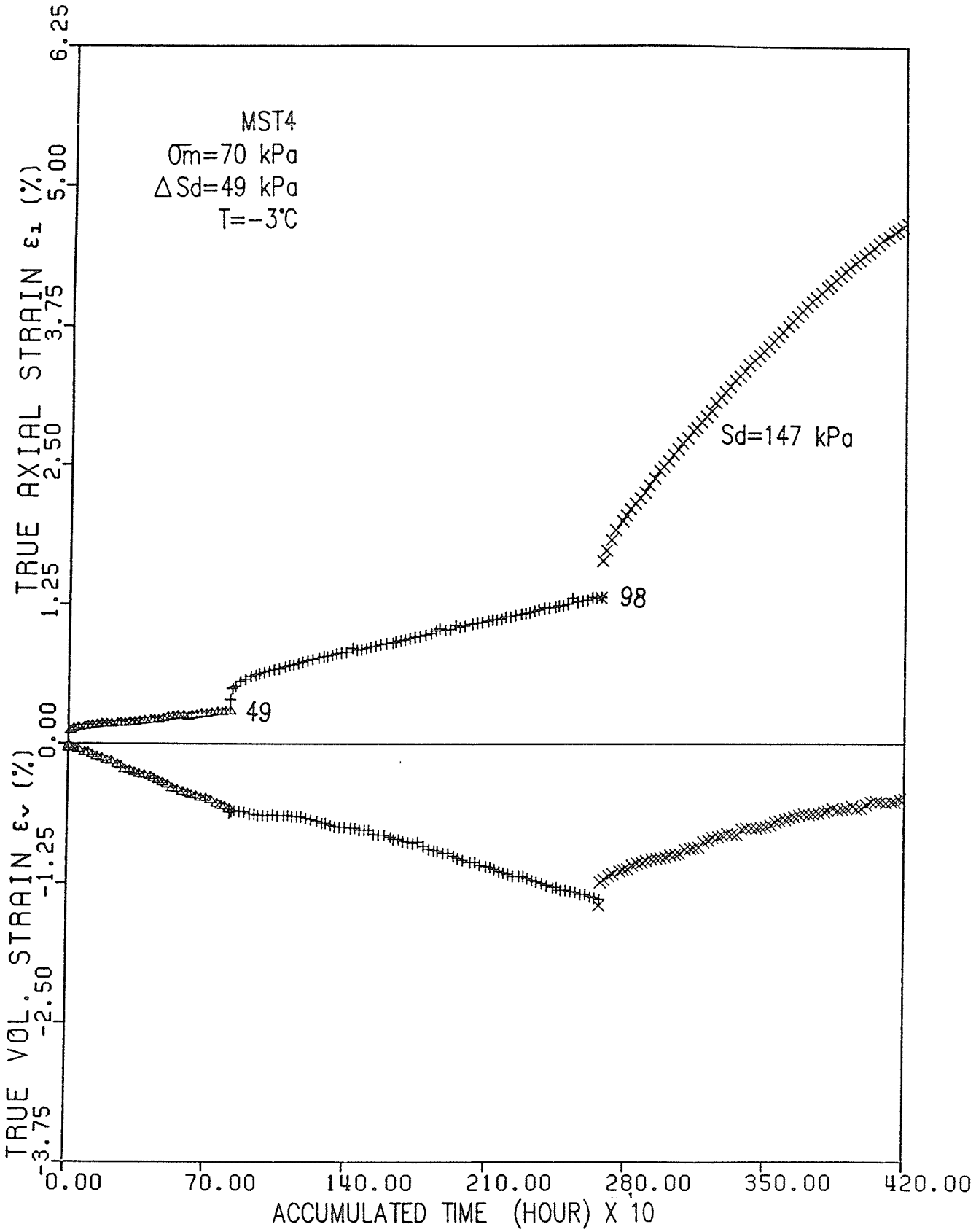


Figure 5.7 True volumetric and true axial strain versus accumulated time (MST4)

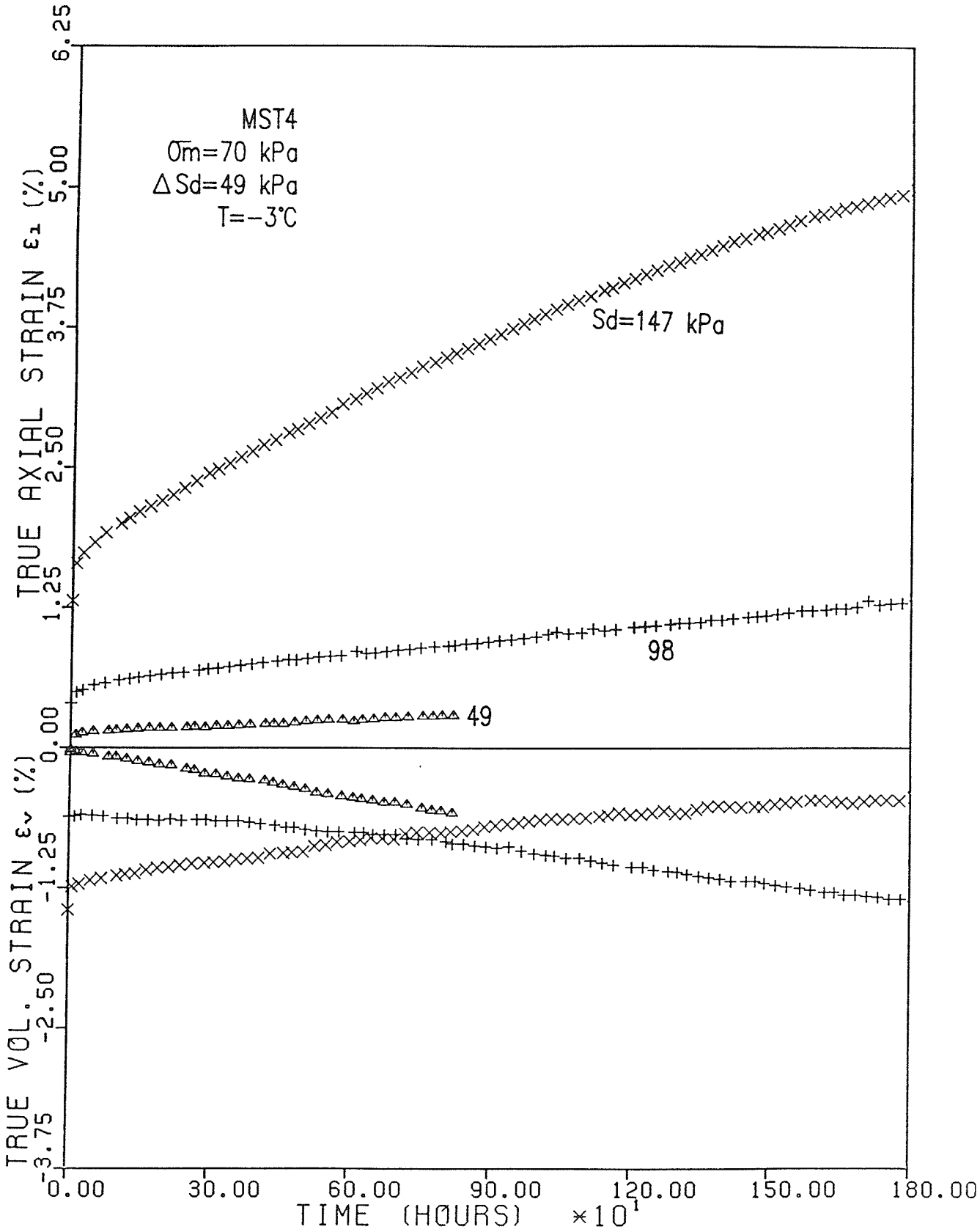


Figure 5.8 True volumetric and true axial strain versus time (MST4)

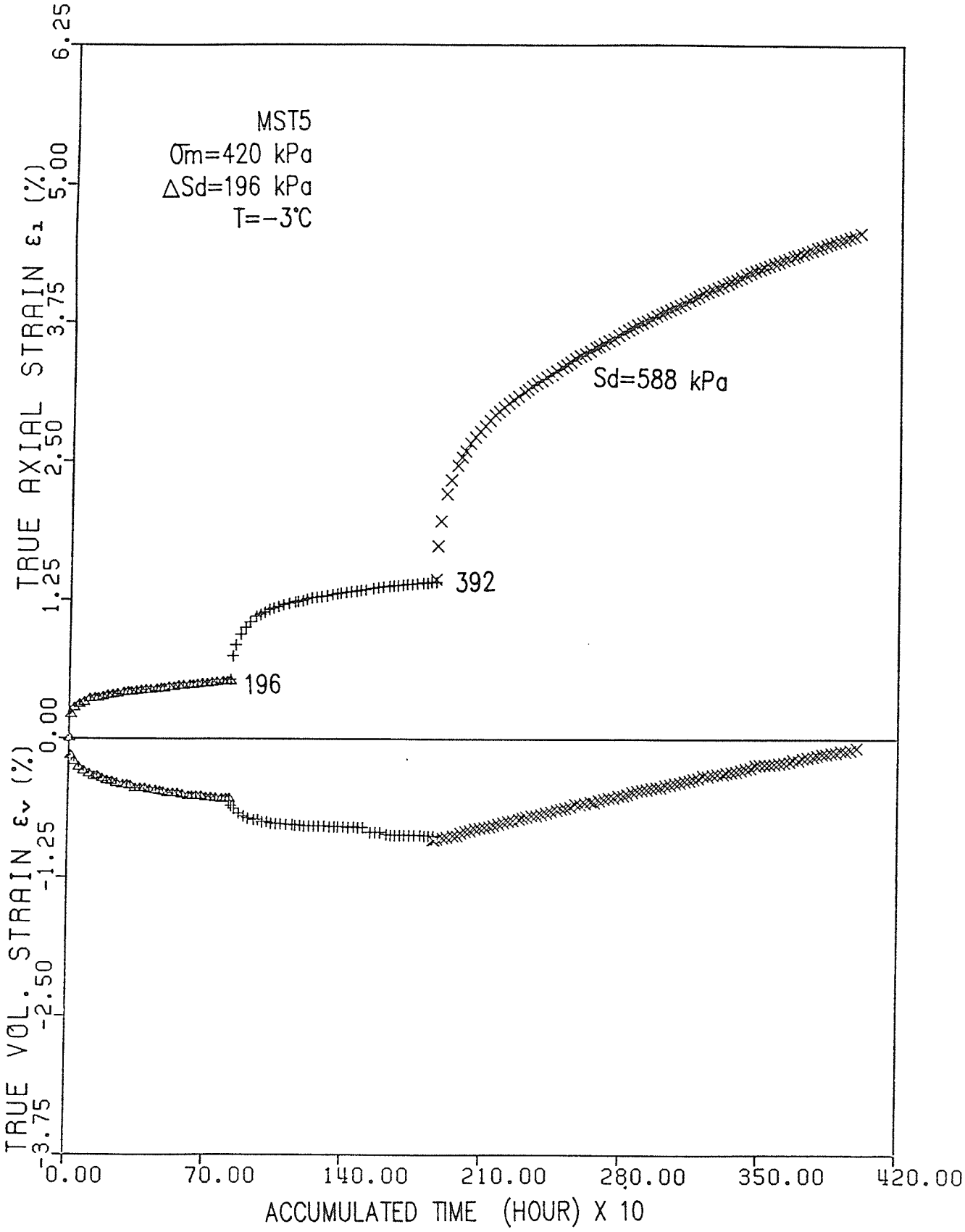


Figure 5.9 True volumetric and true axial strain versus accumulated time (MST5)

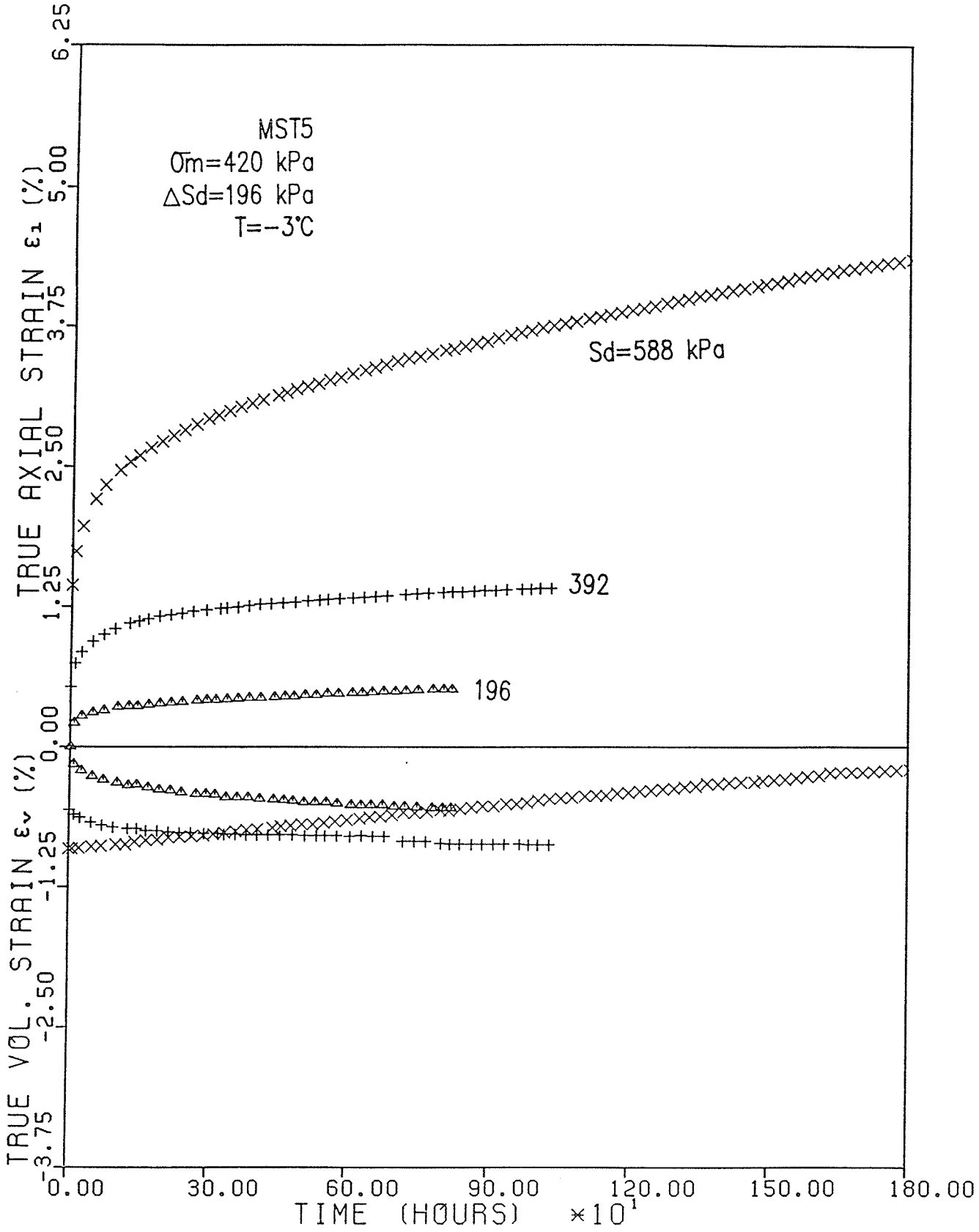


Figure 5.10 True volumetric and true axial strain versus time (MST5)

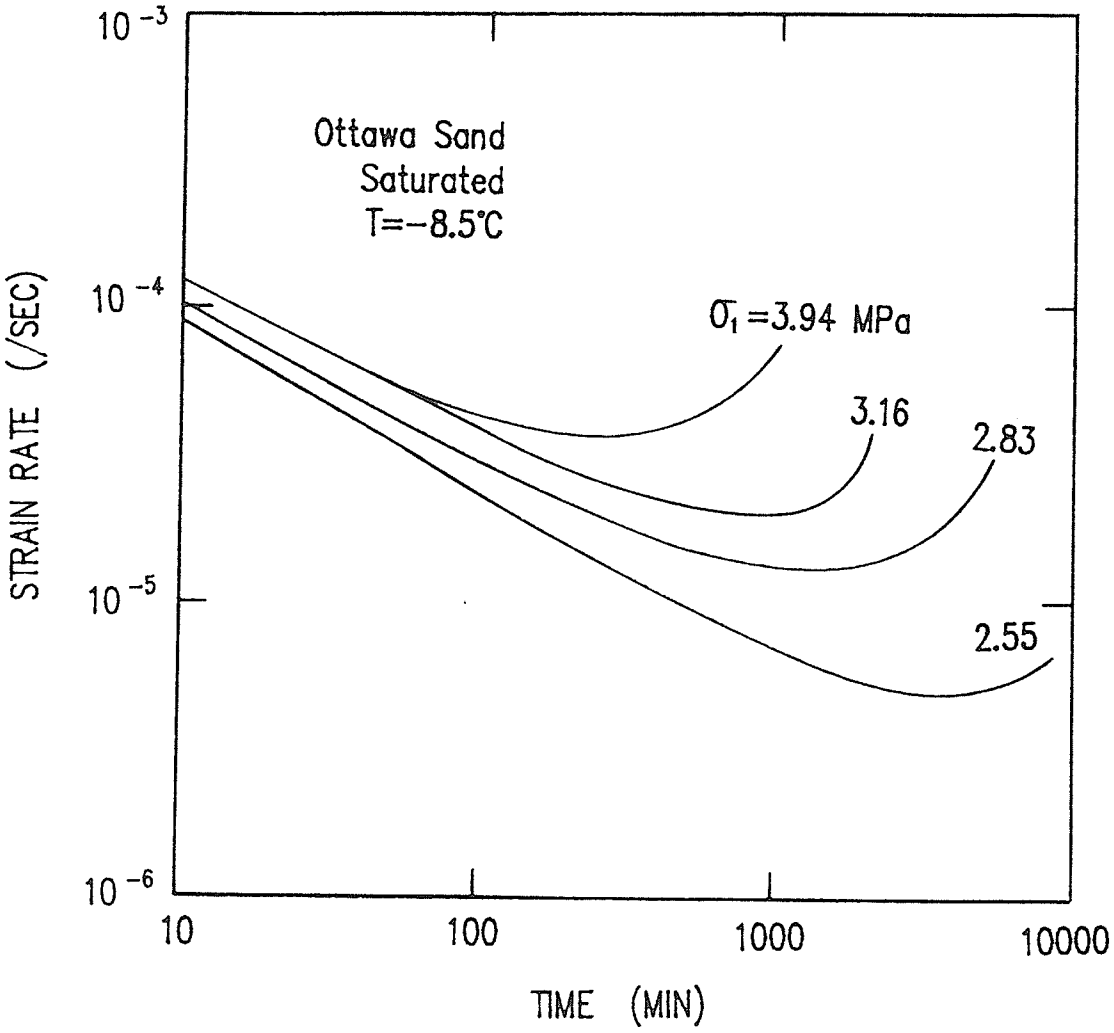


Figure 5.11 Axial strain rate versus time (after Rein et al., 1975)

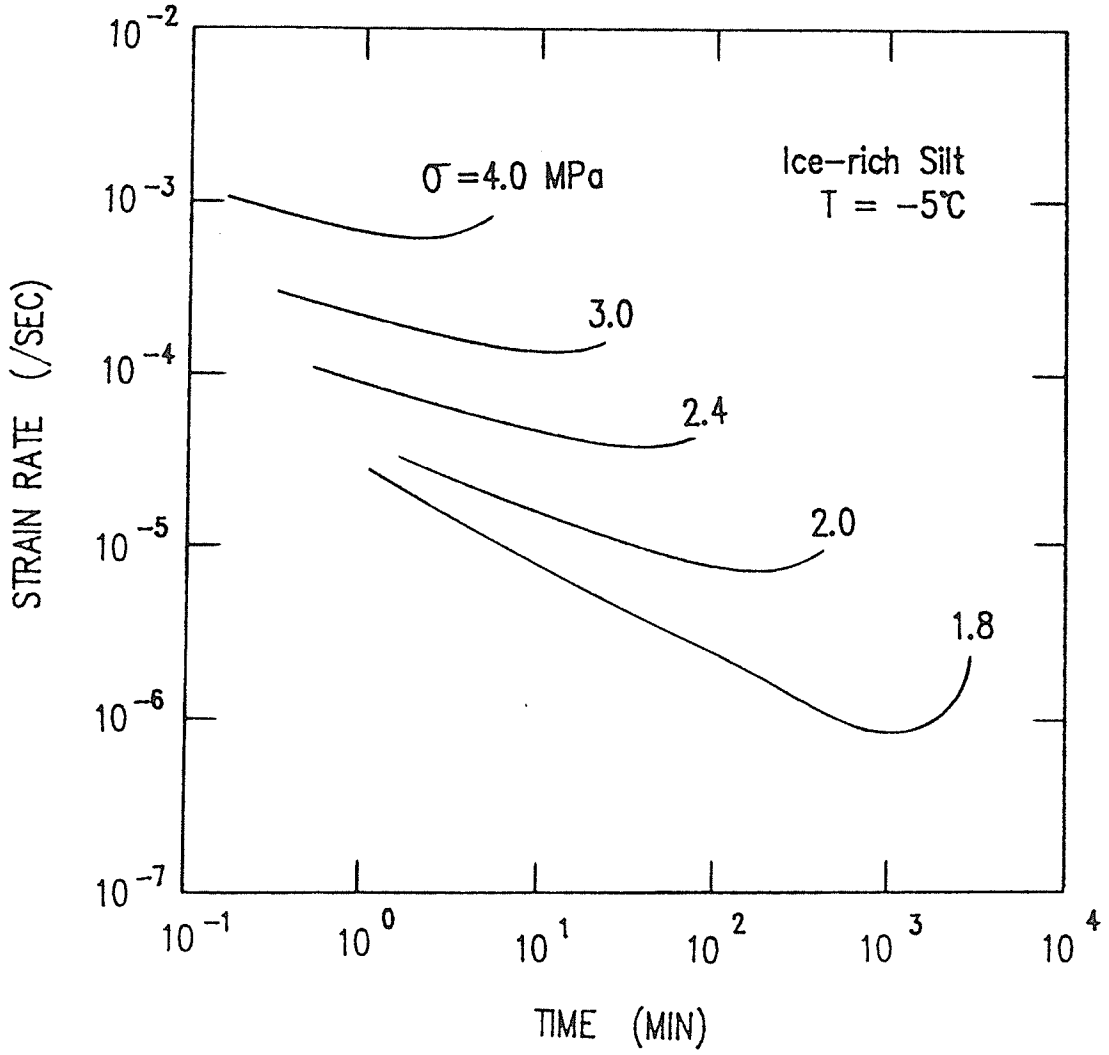


Figure 5.12 Axial strain rate versus time for silt (after Yalin and Carbee, 1984)

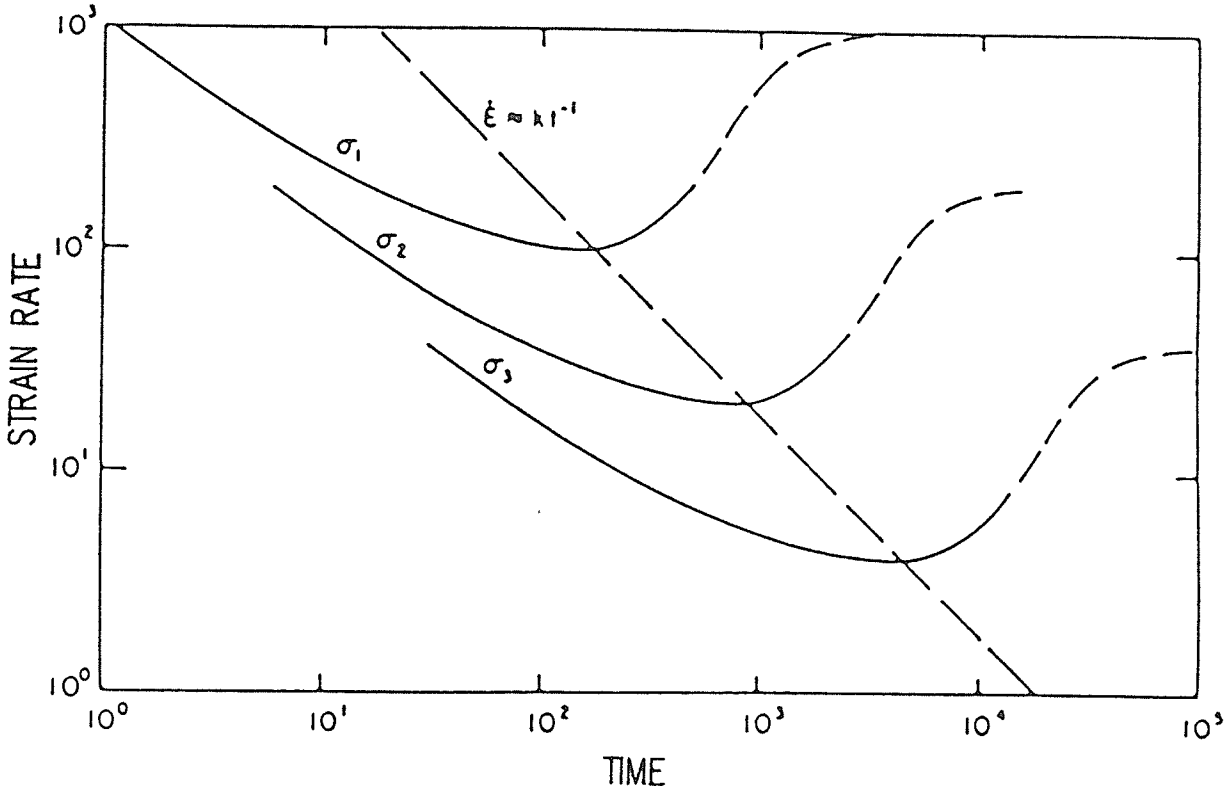


Figure 5.13 Axial strain rate versus time for polycrystalline ice (Mellor, 1979)

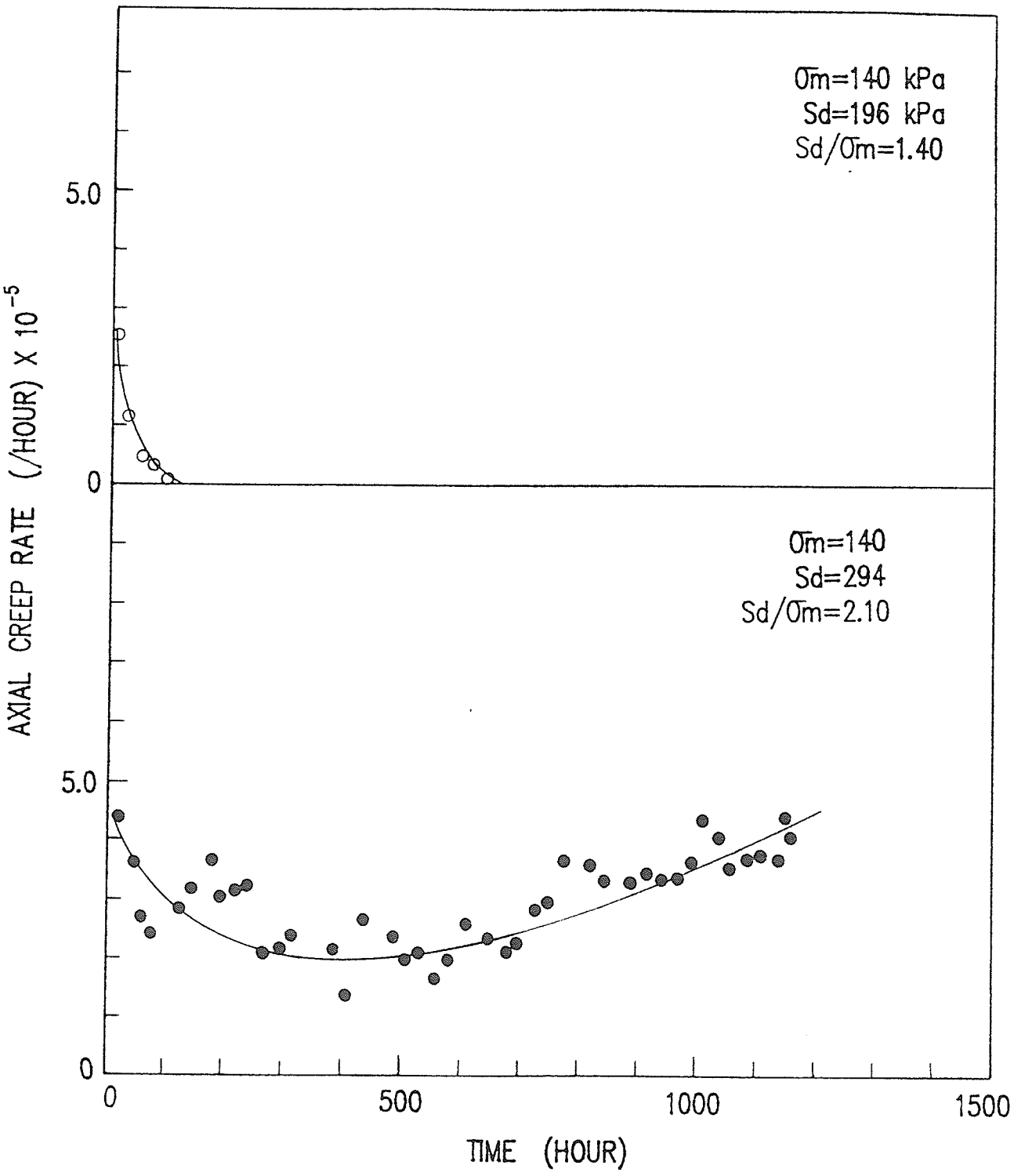


Figure 5.14 Axial creep rate versus time (MST1)

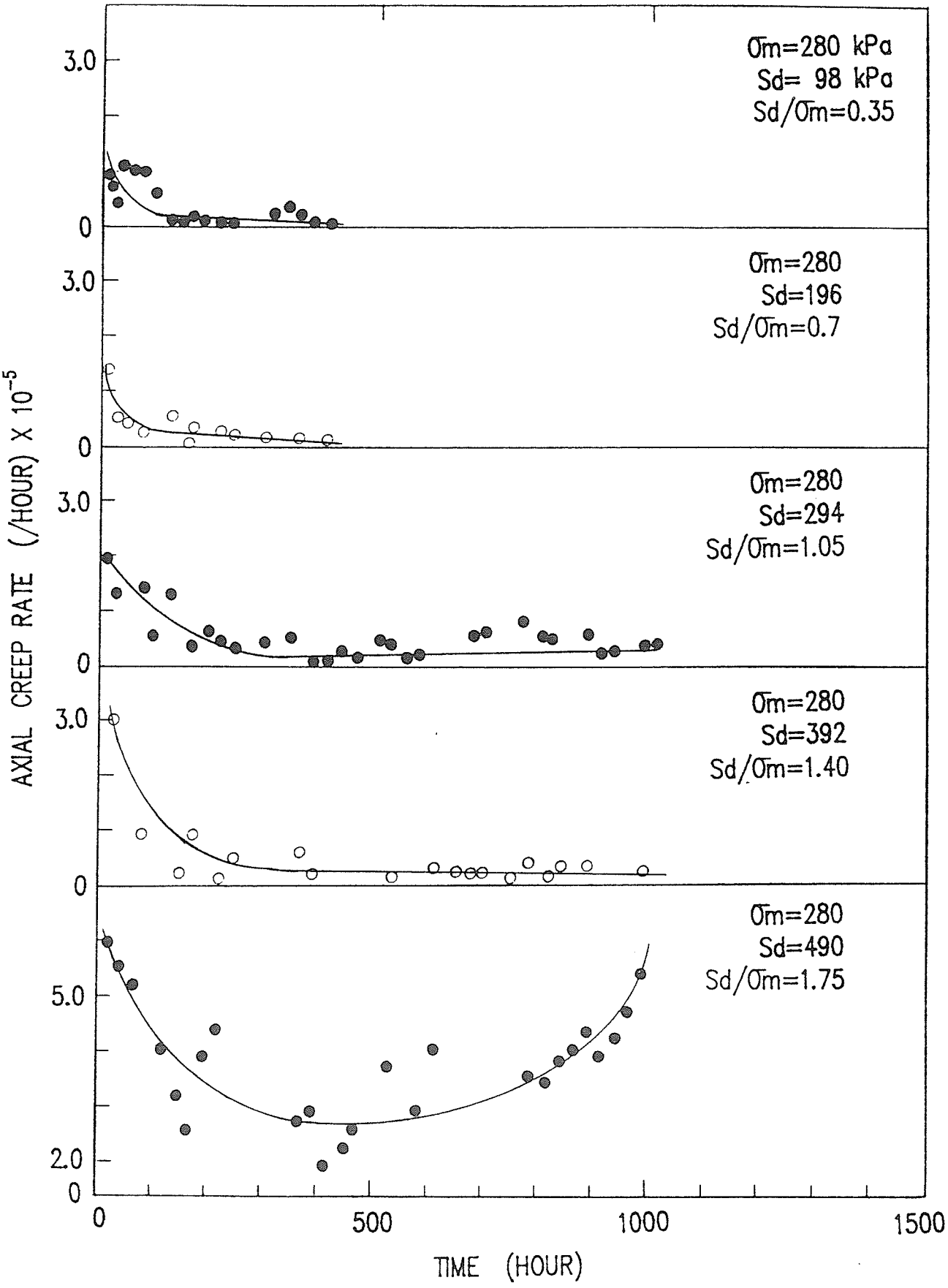


Figure 5.15 Axial creep rate versus time (MST2)

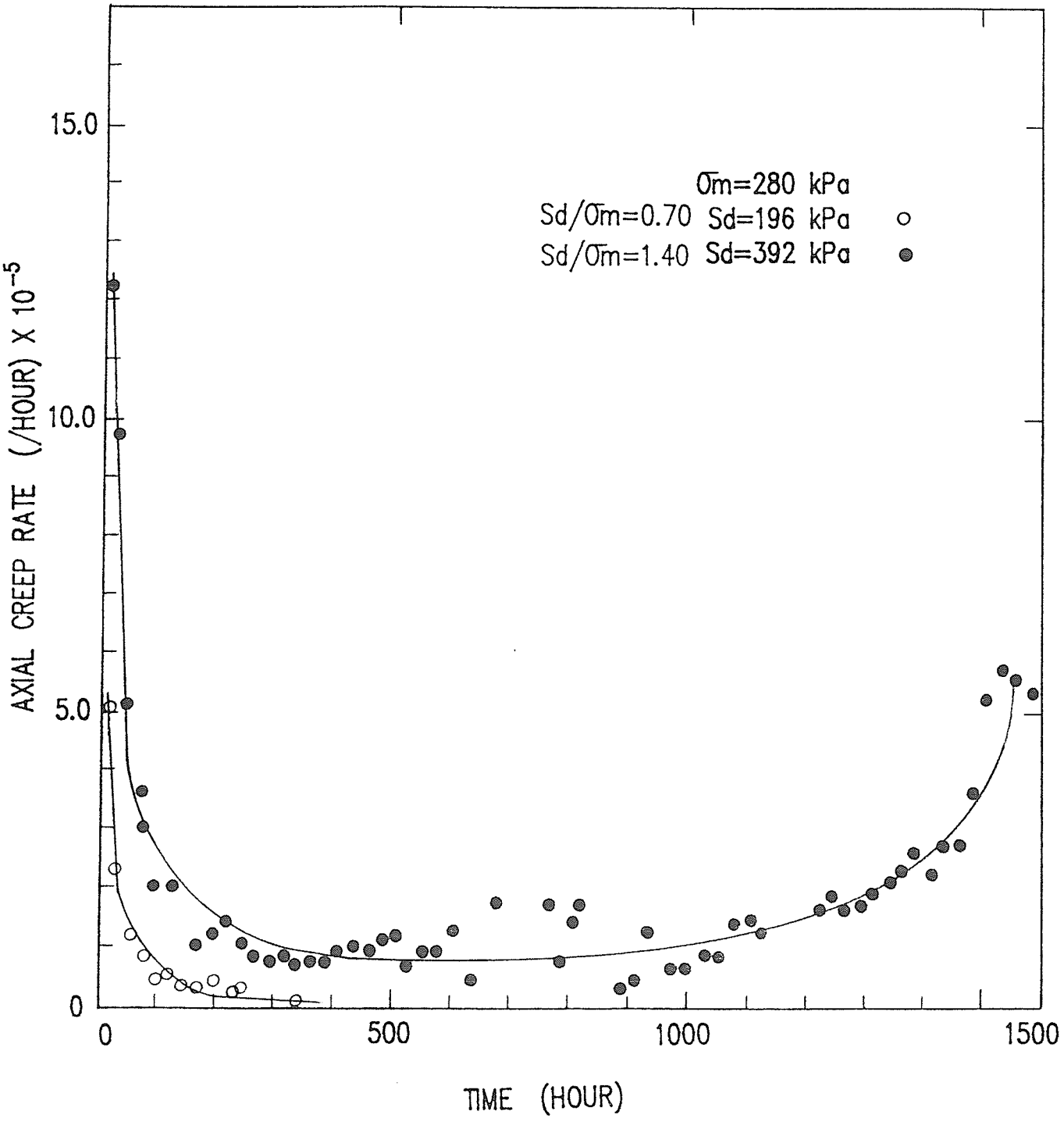


Figure 5.16 Axial creep rate versus time (MST3)

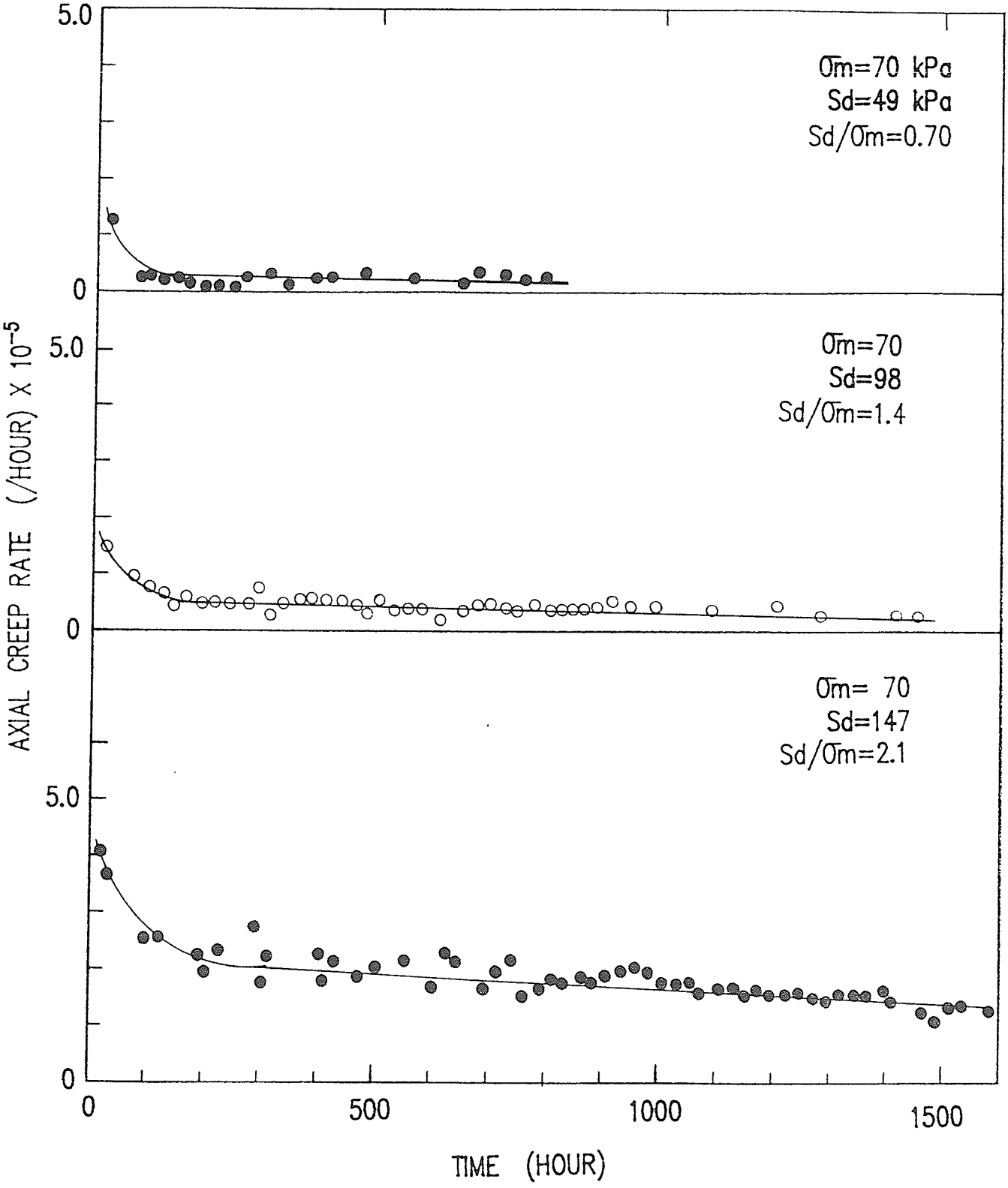


Figure 5.17 Axial creep rate versus time (MST4)

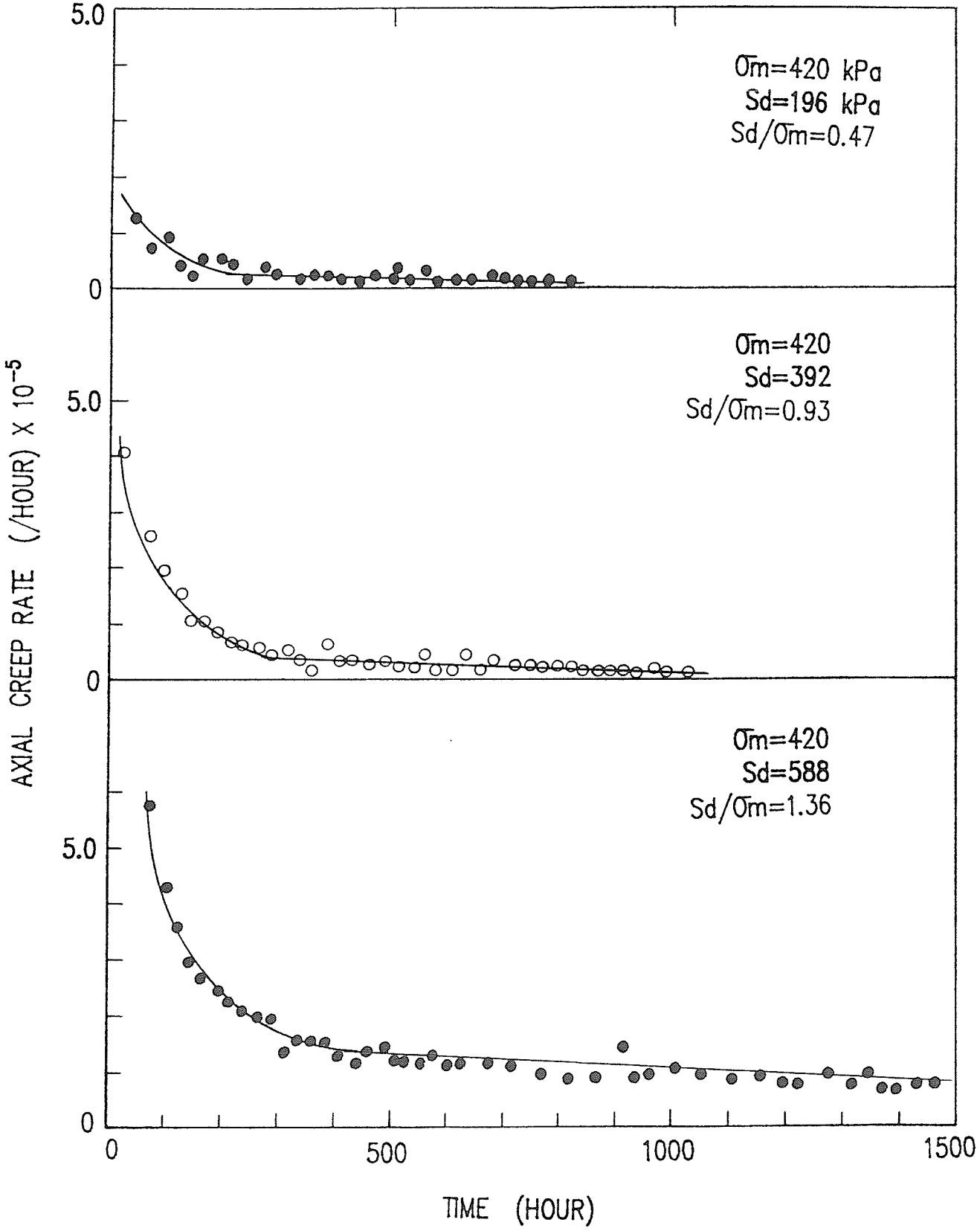


Figure 5.18 Axial creep rate versus time (MST5)

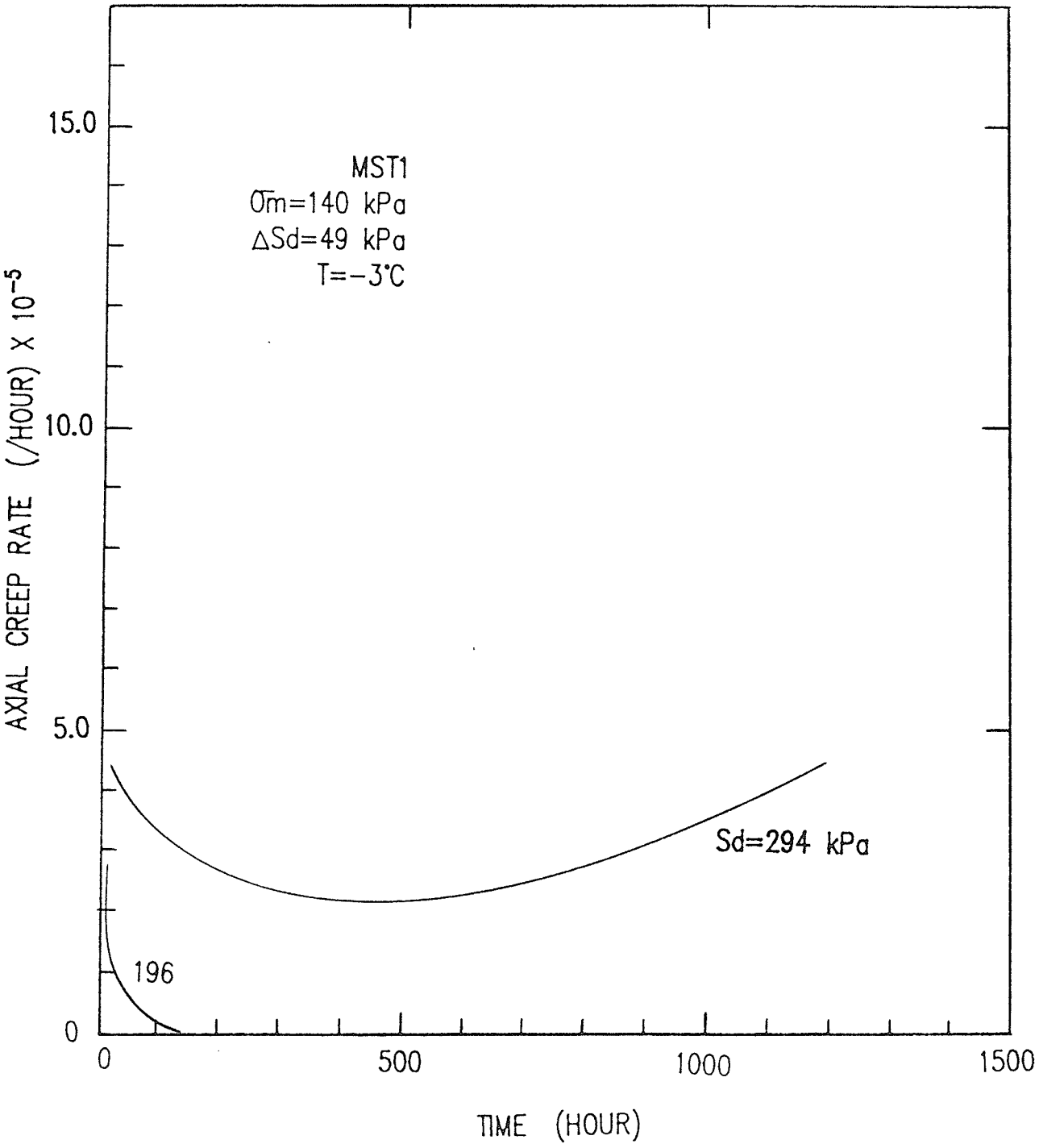


Figure 5.19 Axial creep rate versus time for $\bar{\sigma}_m$=140 kPa

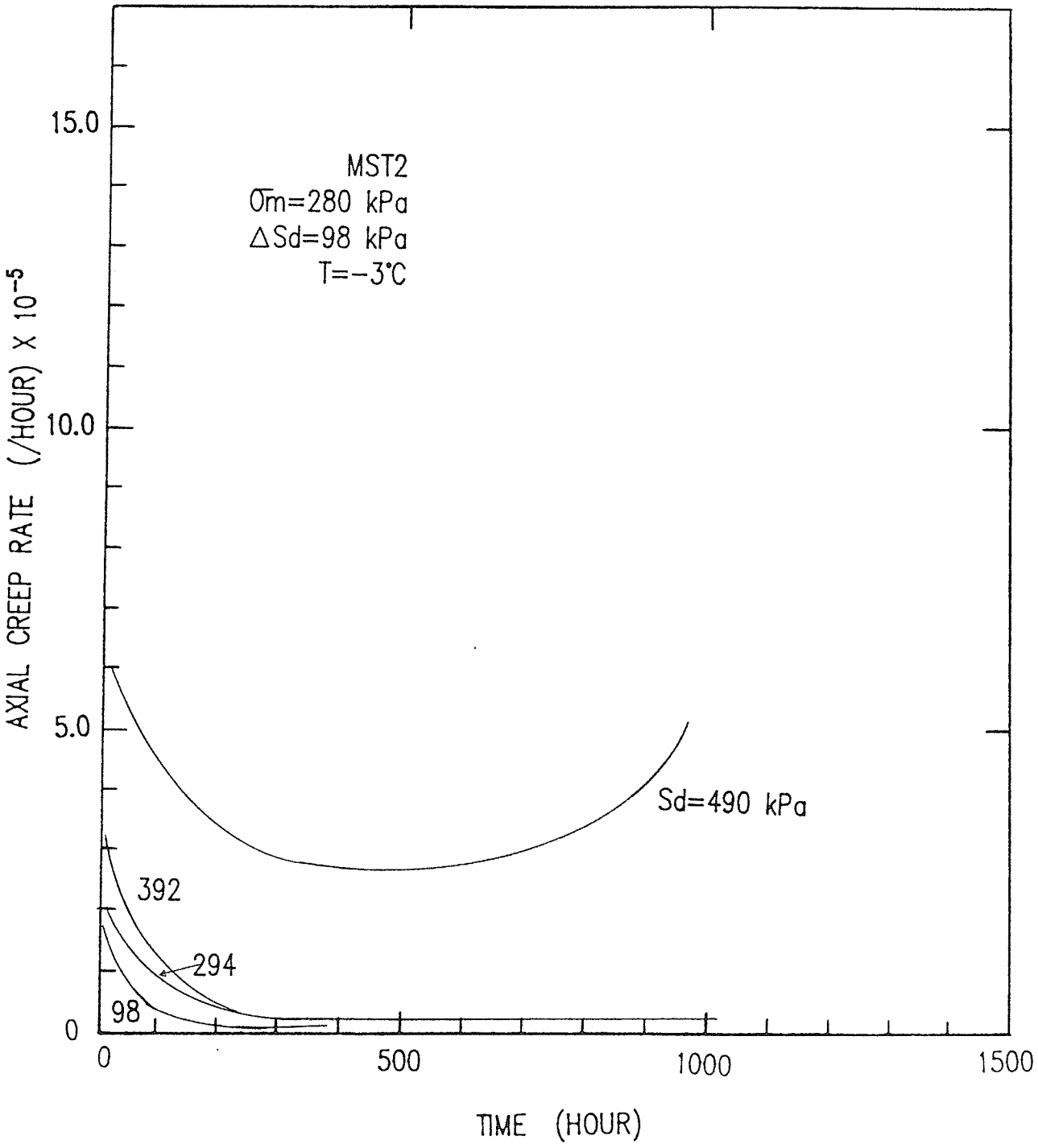


Figure 5.20 Axial creep rate versus time for σm=280 kPa

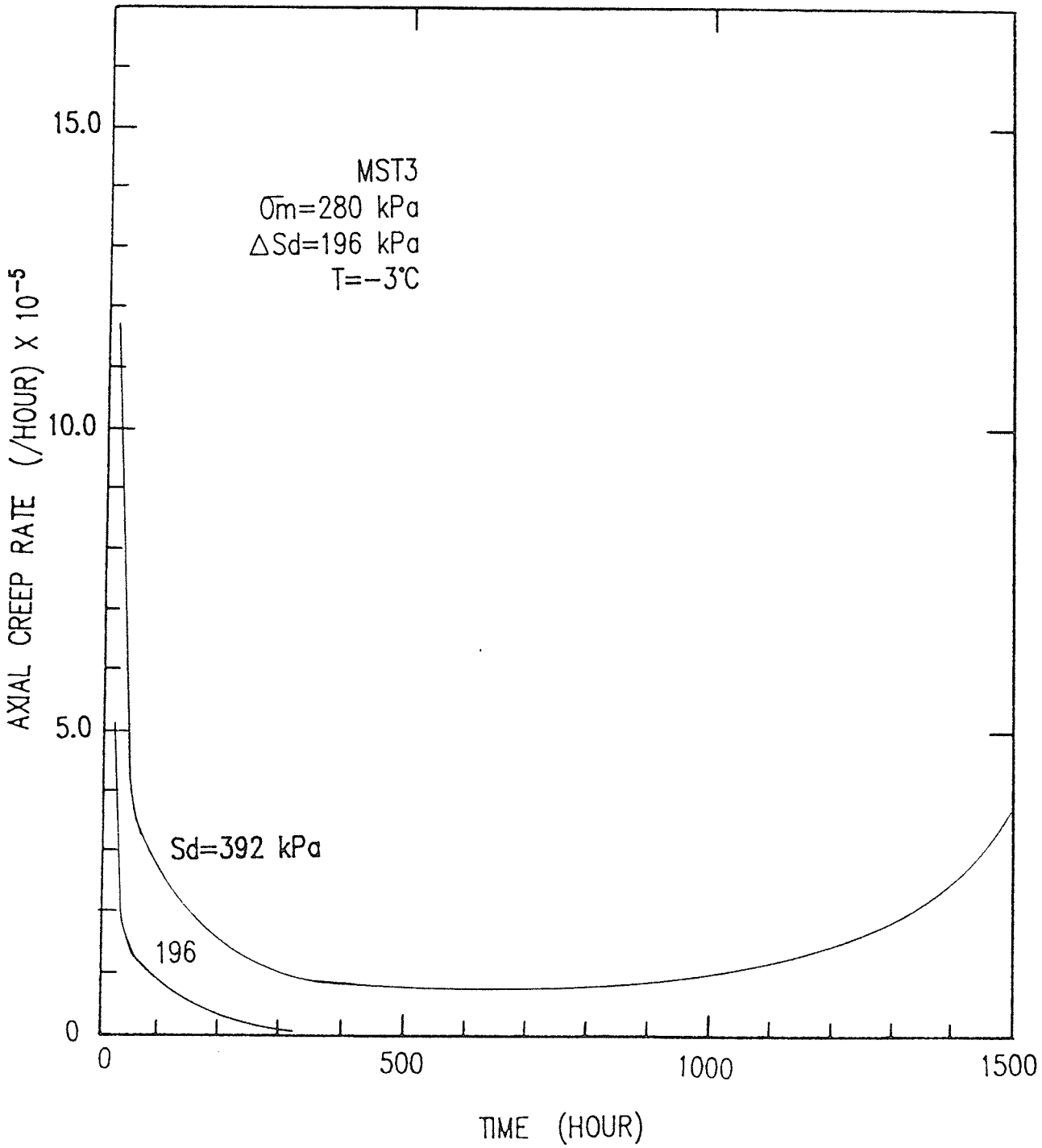


Figure 5.21 Axial creep rate versus time for $\bar{\sigma}_m$=280 kPa

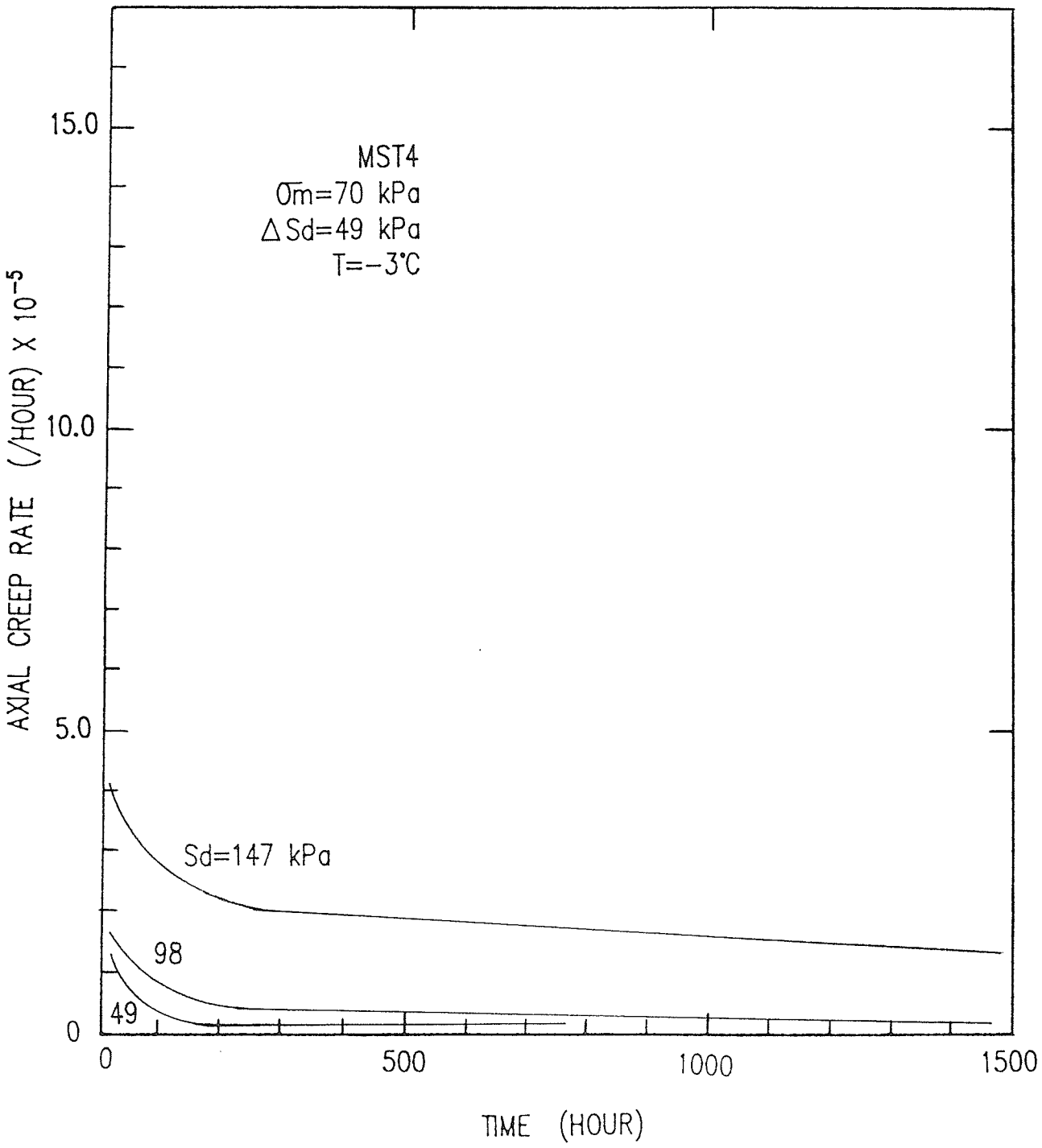


Figure 5.22 Axial creep rate versus time for $\bar{\sigma}_m$=70 kPa

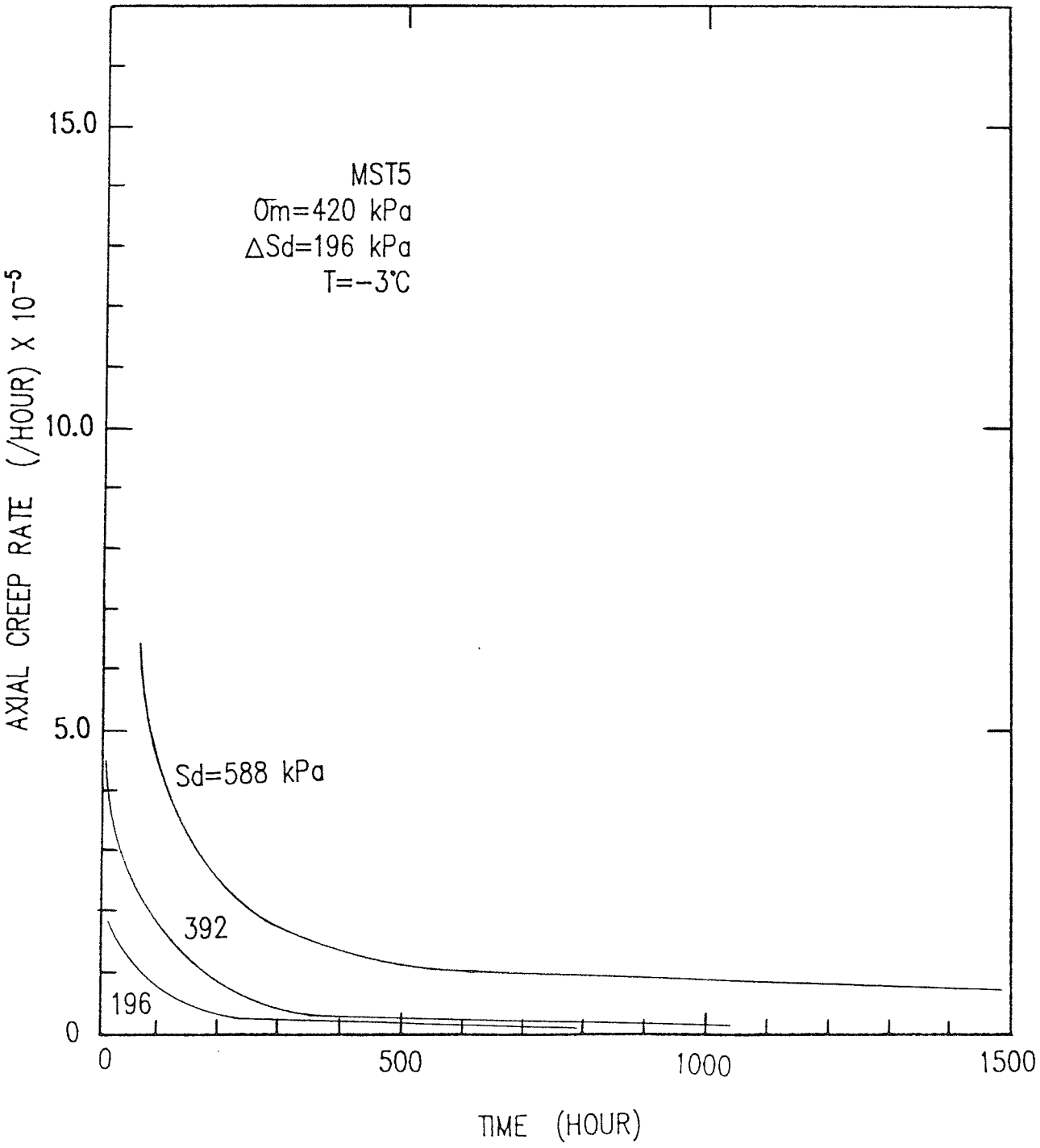


Figure 5.23 Axial creep rate versus time for $\bar{\sigma}_m$=420 kPa

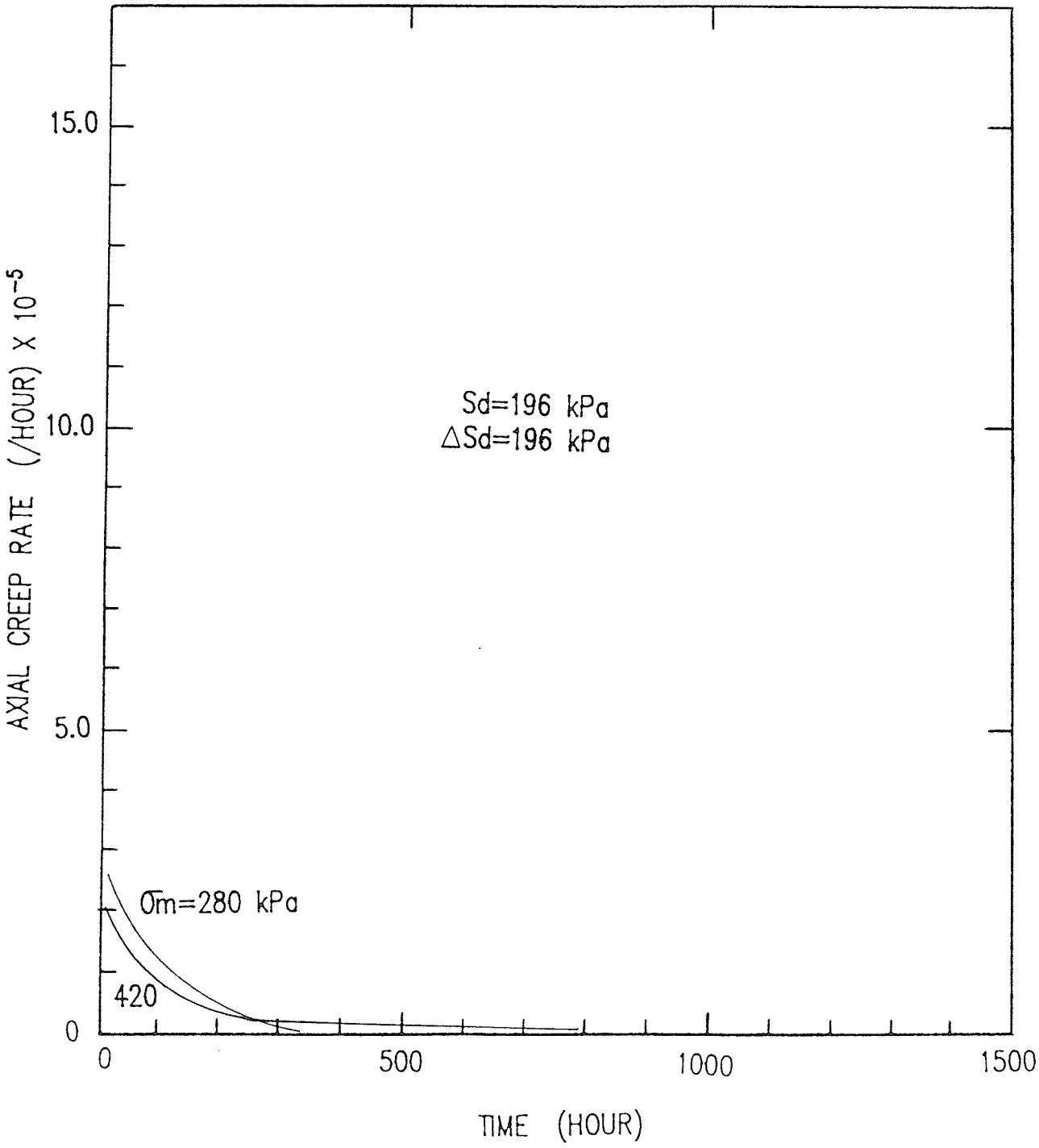


Figure 5.24 Axial creep rate versus time for Sd=196 kPa

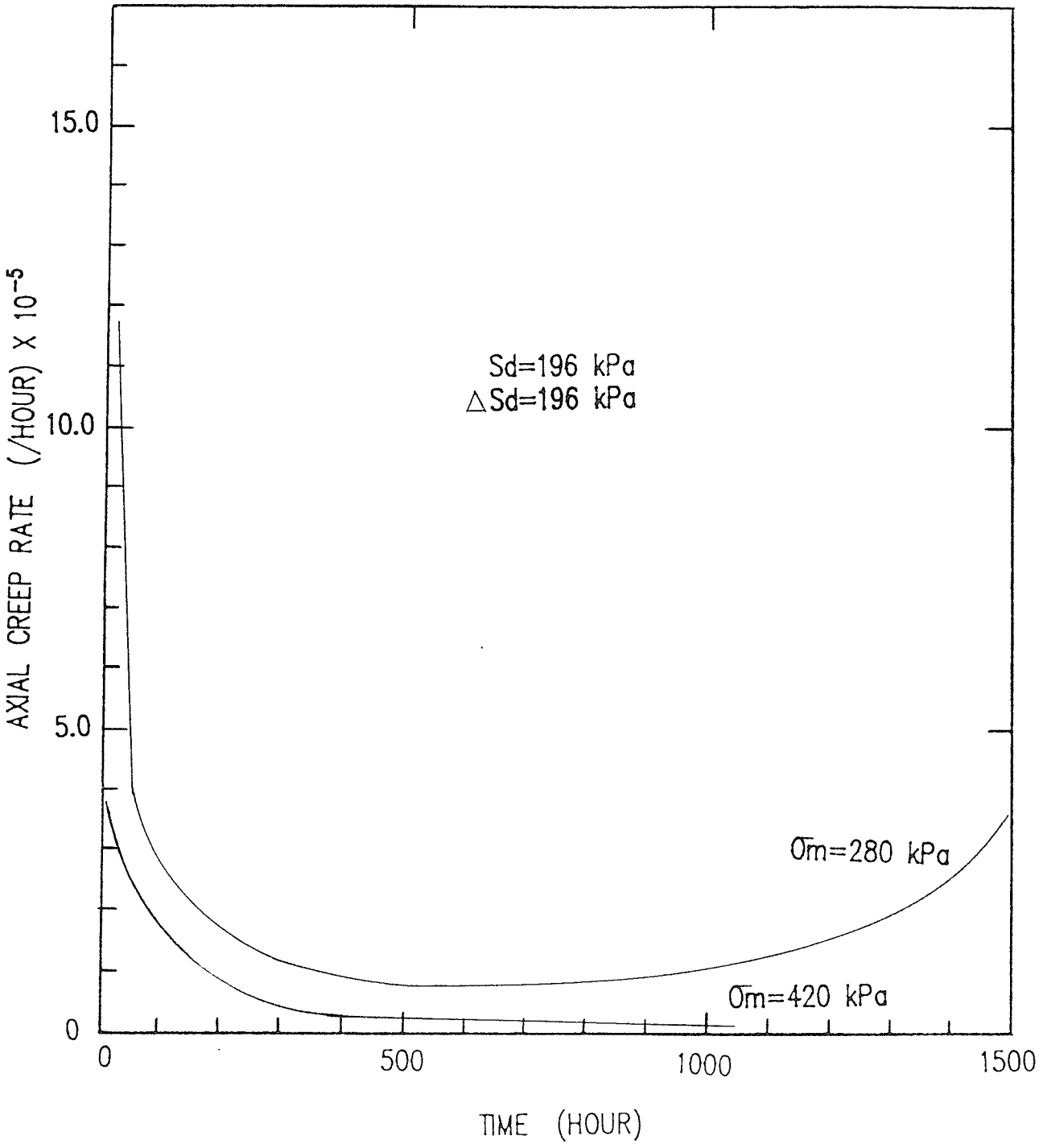


Figure 5.25 Axial creep rate versus time for Sd=392 kPa

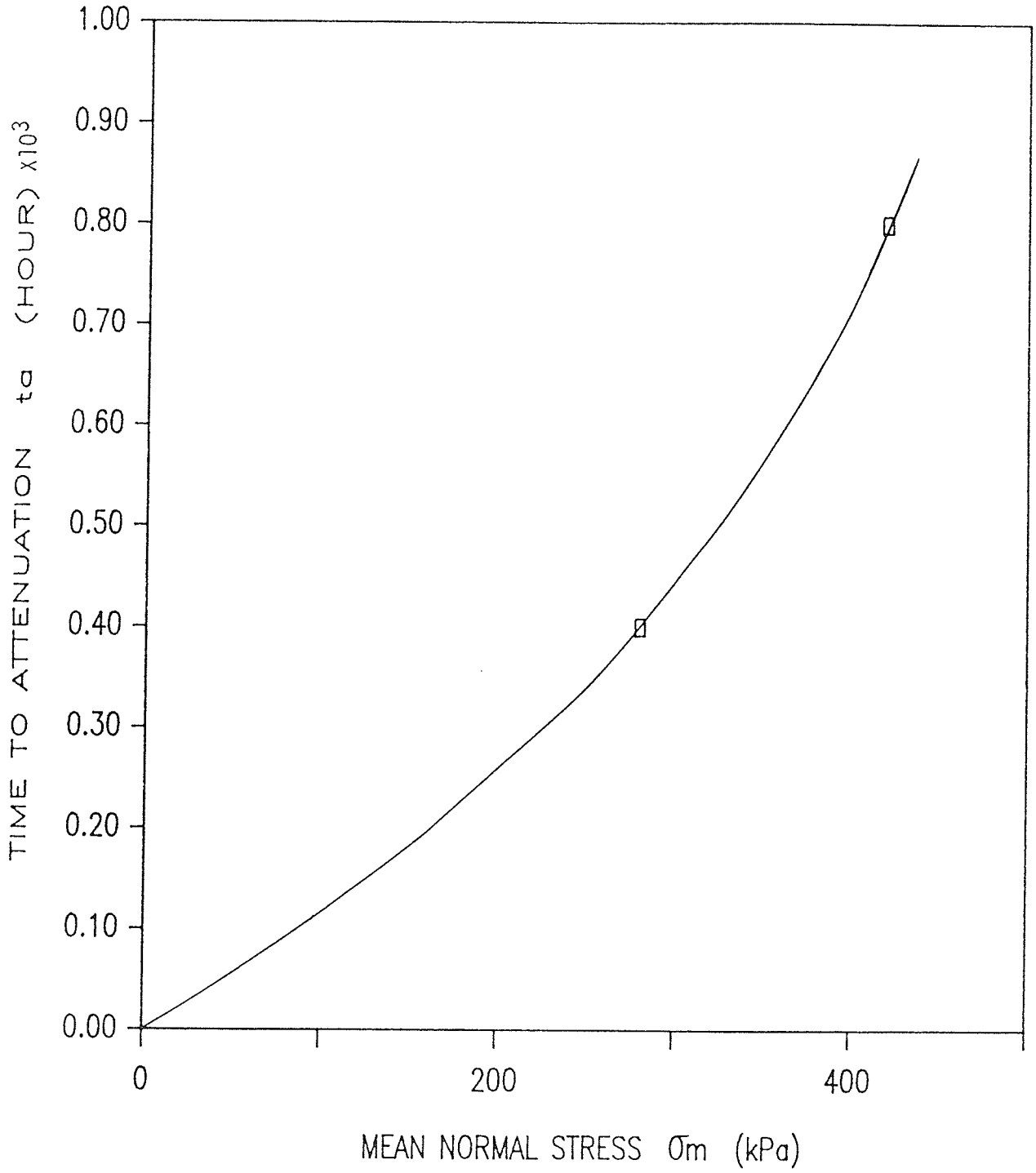


Figure 5.26 Time to attenuation versus mean normal stress

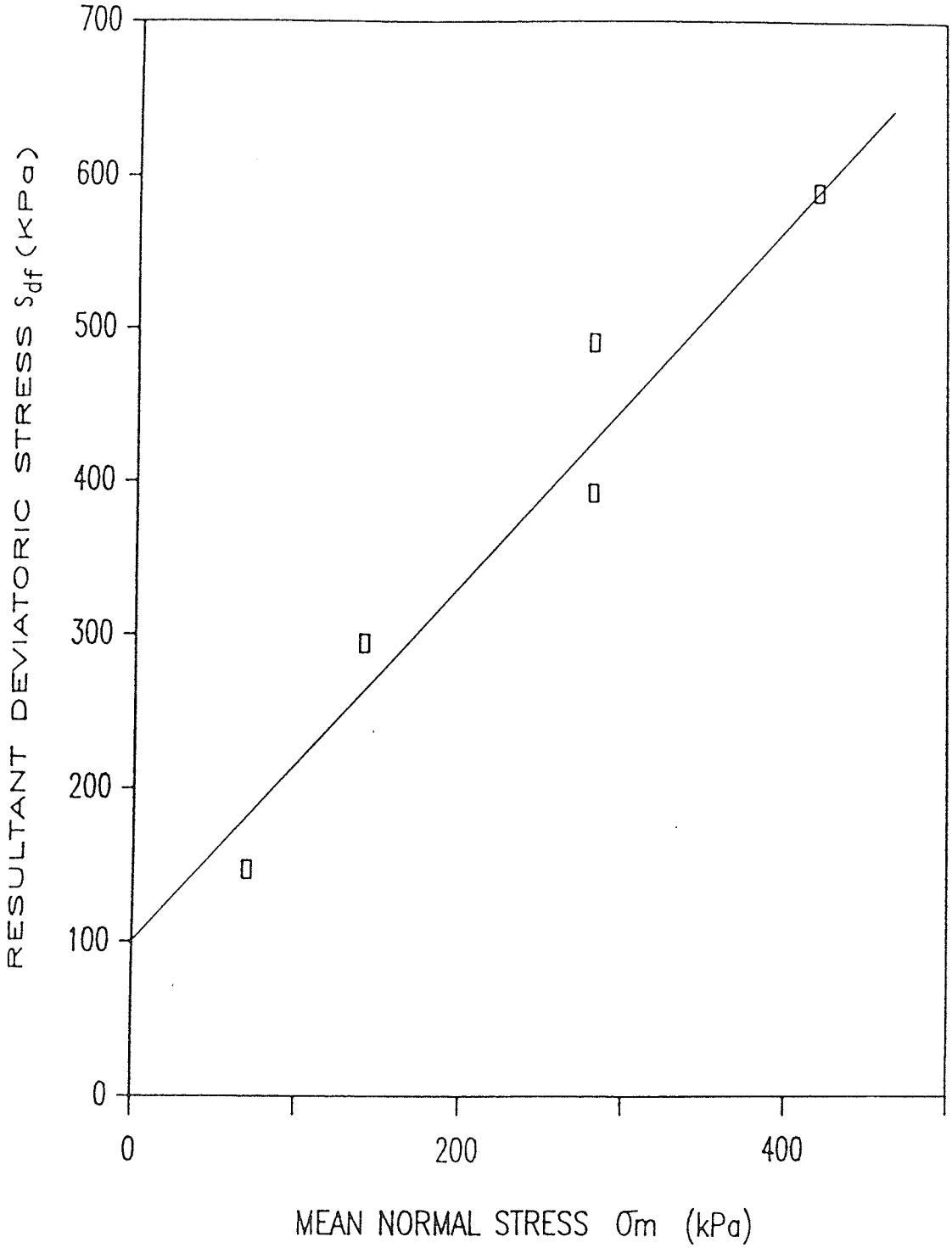


Figure 5.27 Resultant deviatoric stress at failure versus mean normal stress

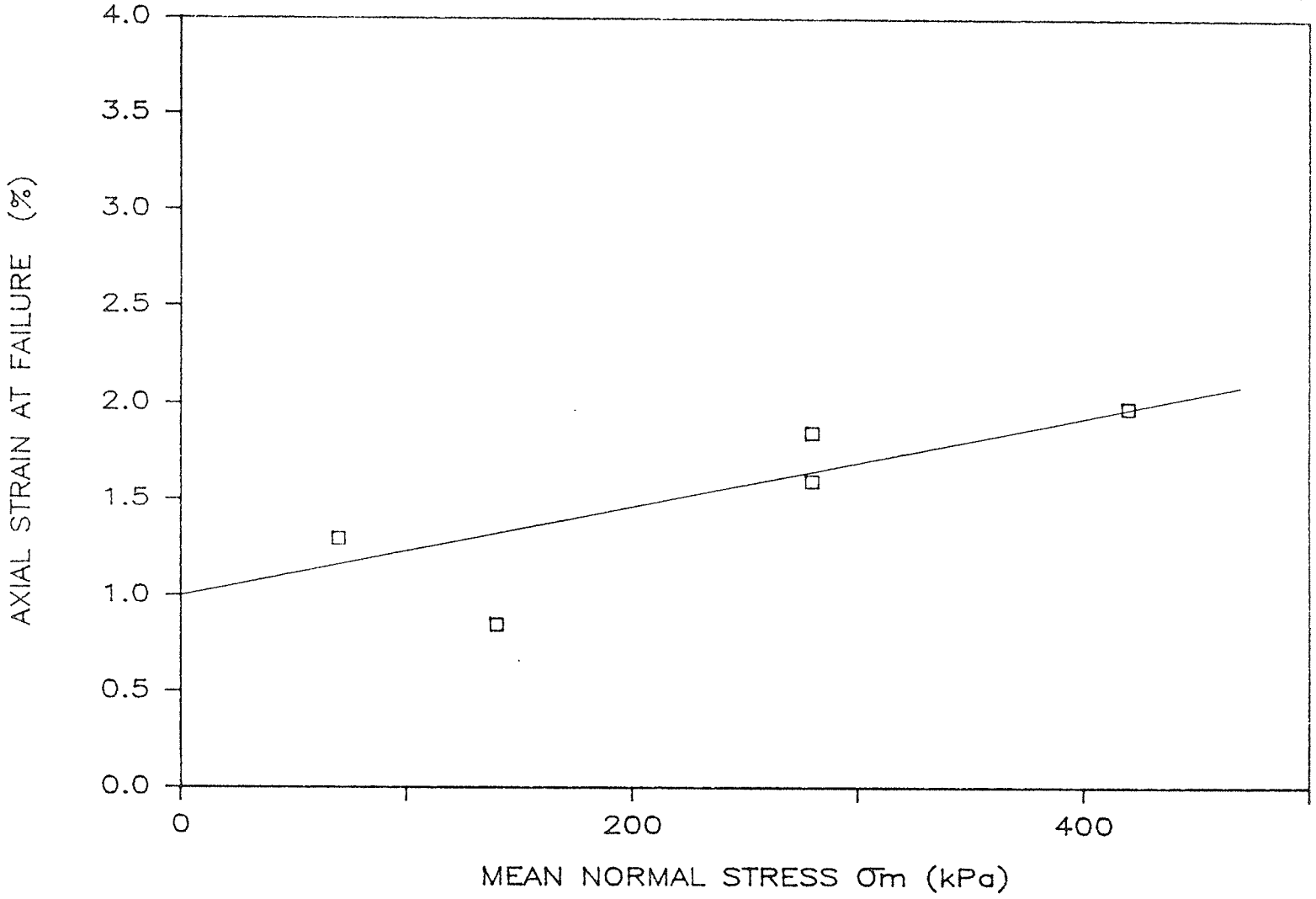


Figure 5.28 Axial strain at failure versus mean normal stress

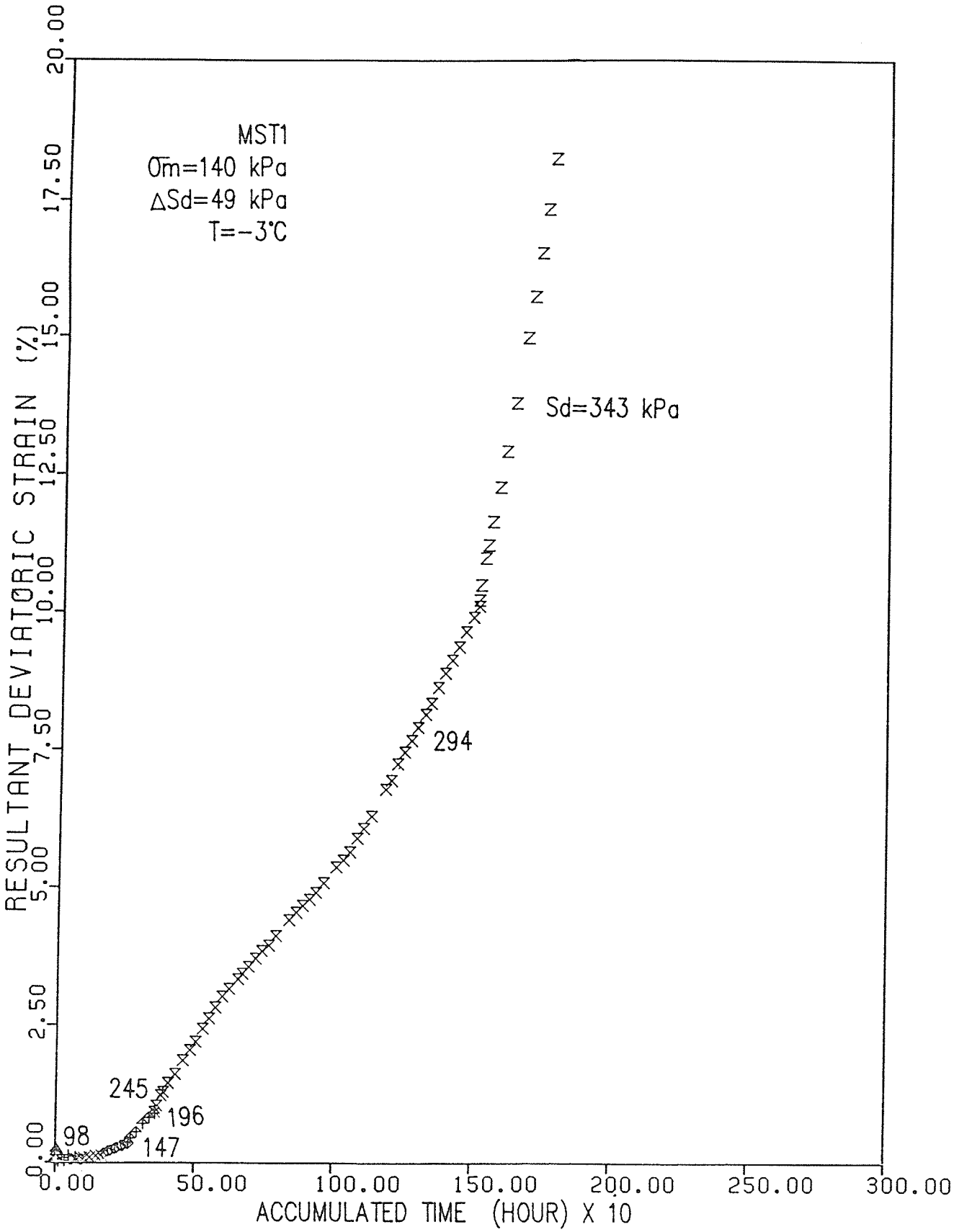


Figure 5.29 Resultant deviatoric strain versus accumulated time (MST1)

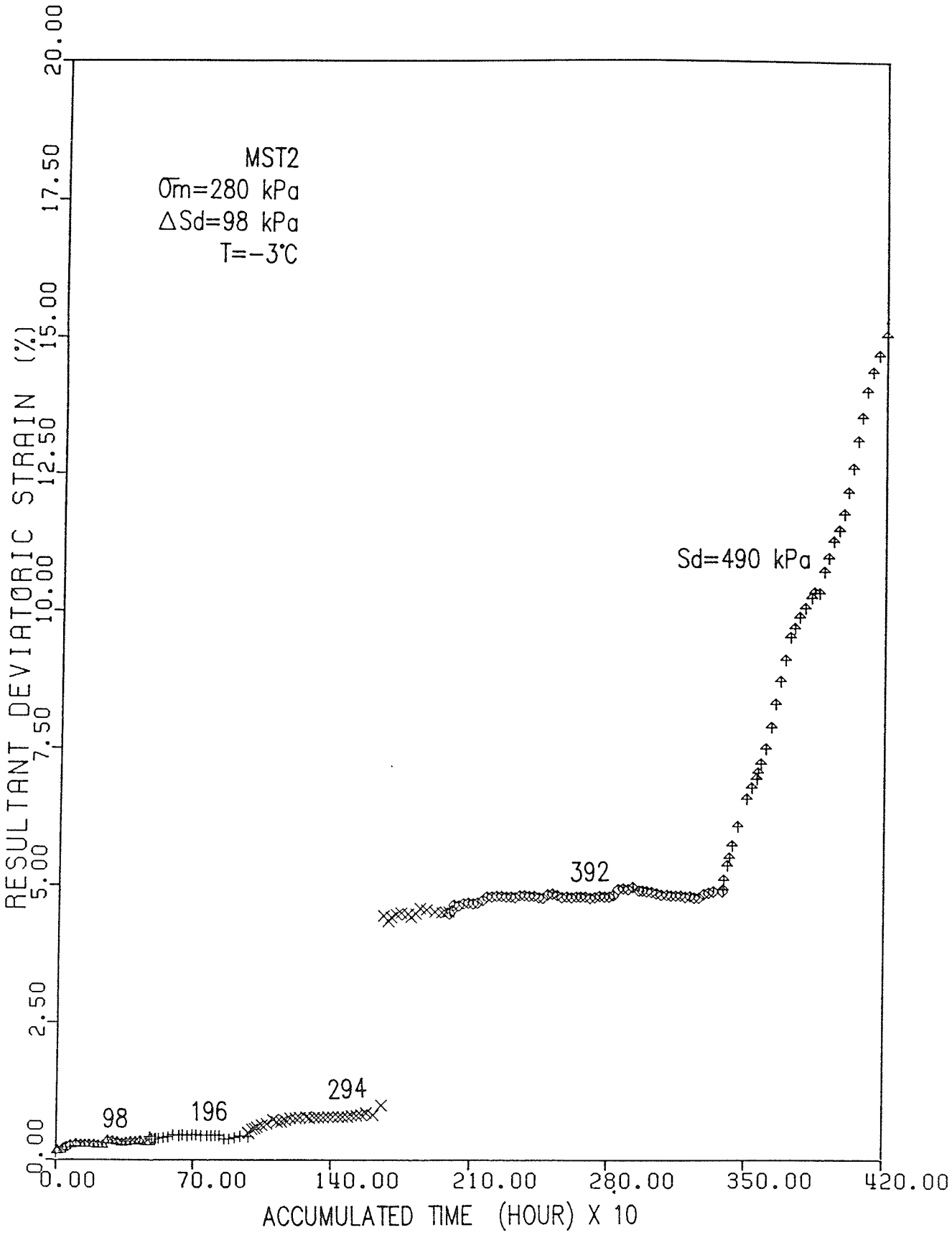


Figure 5.30 Resultant deviatoric strain versus accumulated time (MST2)

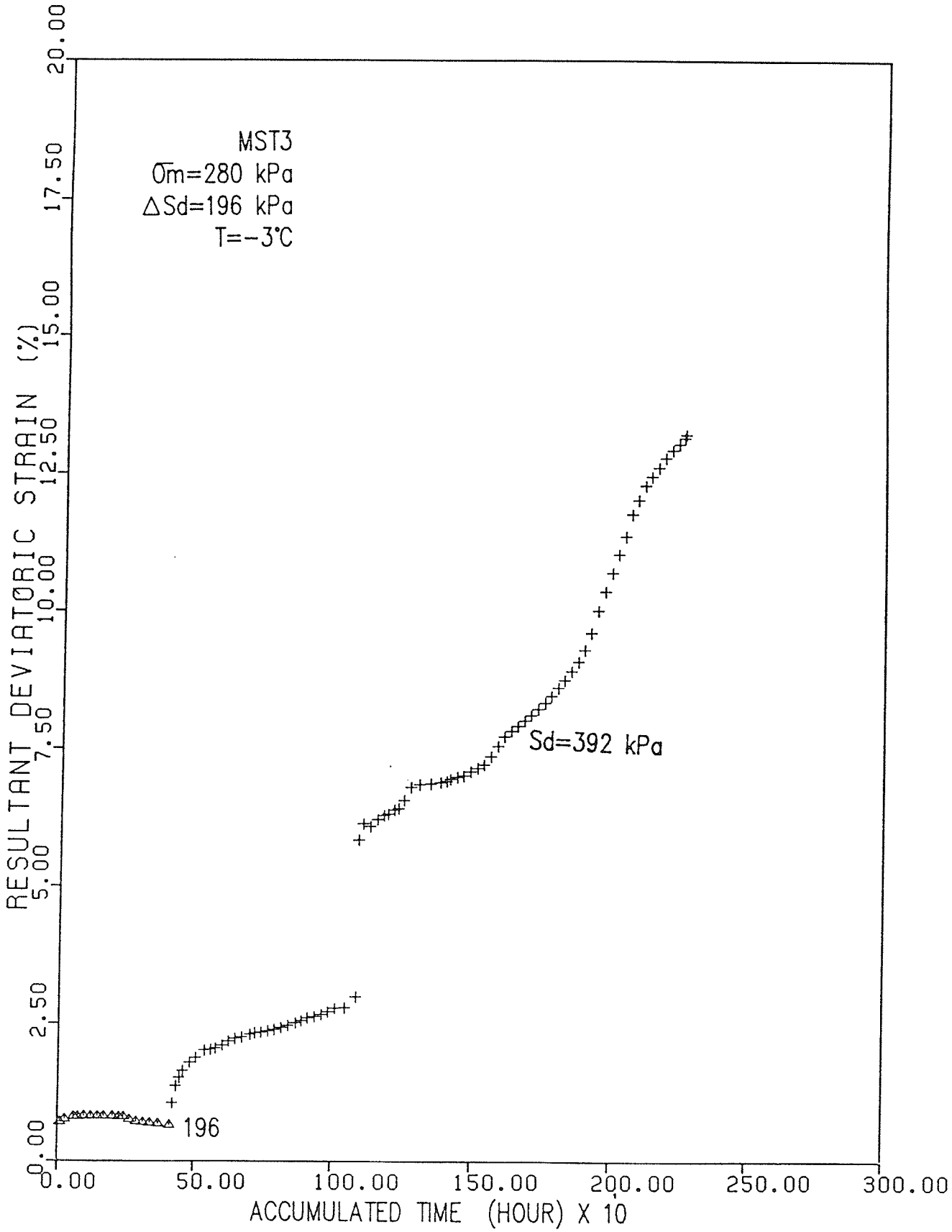


Figure 5.31 Resultant deviatoric strain versus accumulated time (MST3)

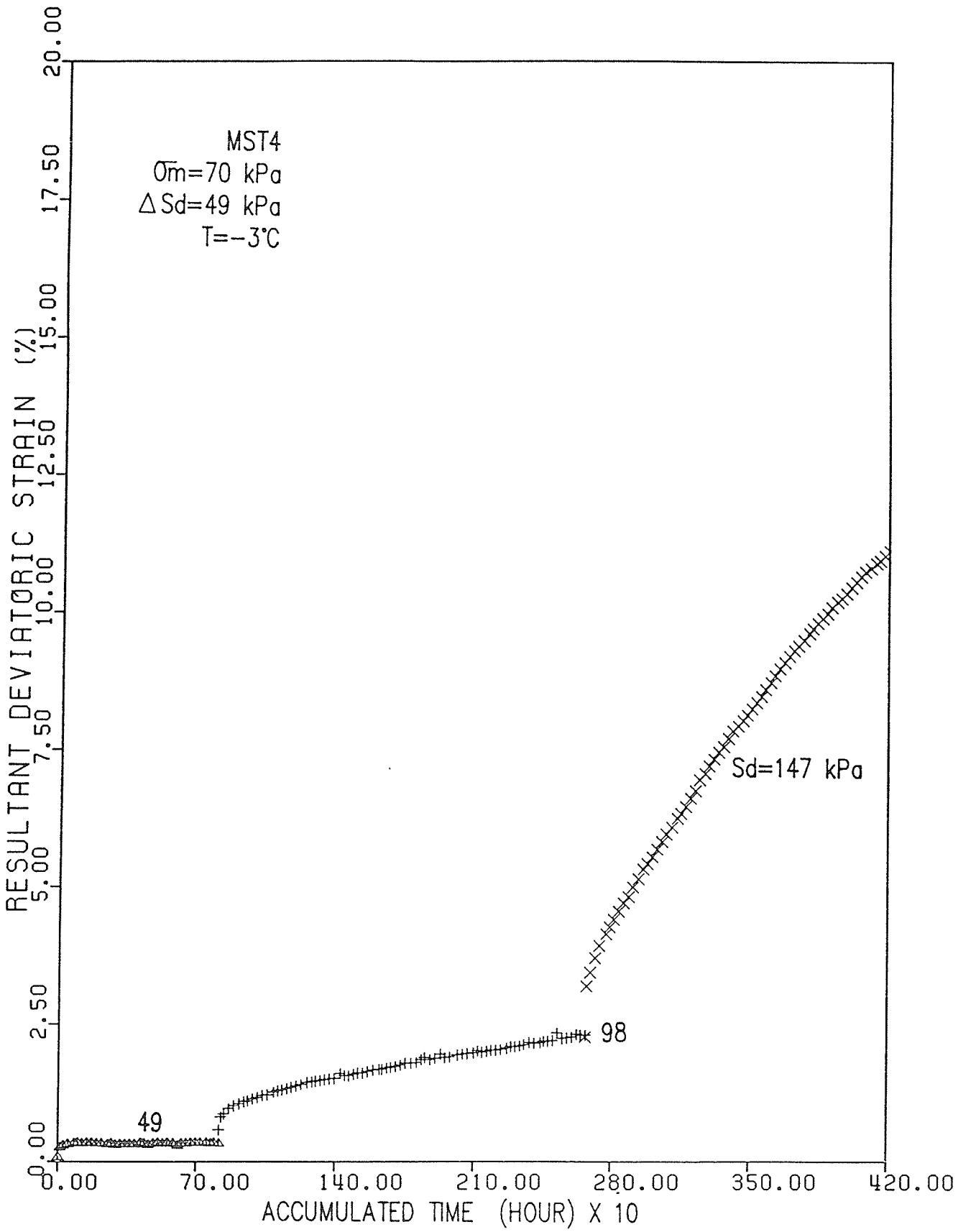


Figure 5.32 Resultant deviatoric strain versus accumulated time (MST4)

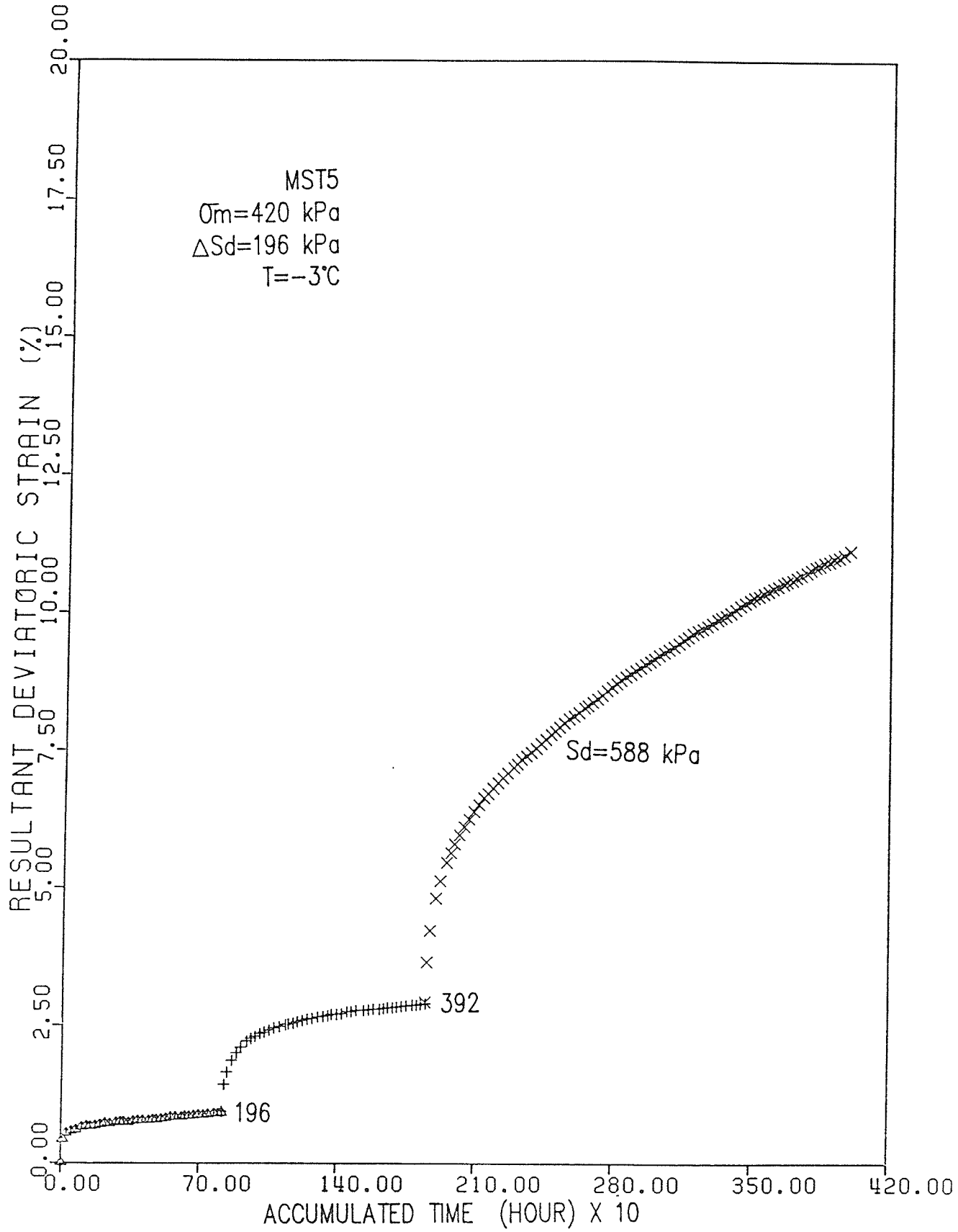


Figure 5.33 Resultant deviatoric strain versus accumulated time (MST5)

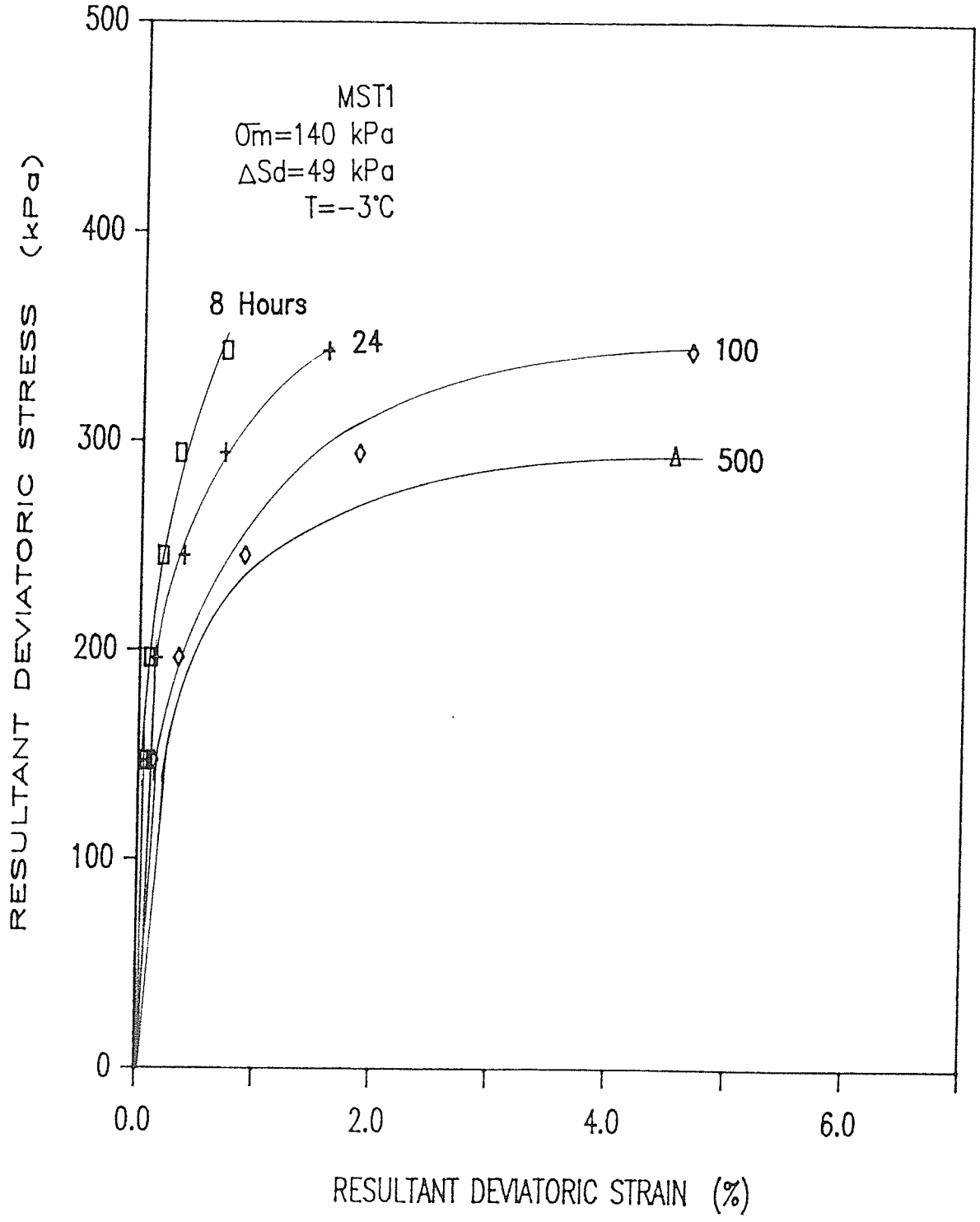


Figure 5.34 Resultant deviatoric stress versus resultant deviatoric strain (MST1)

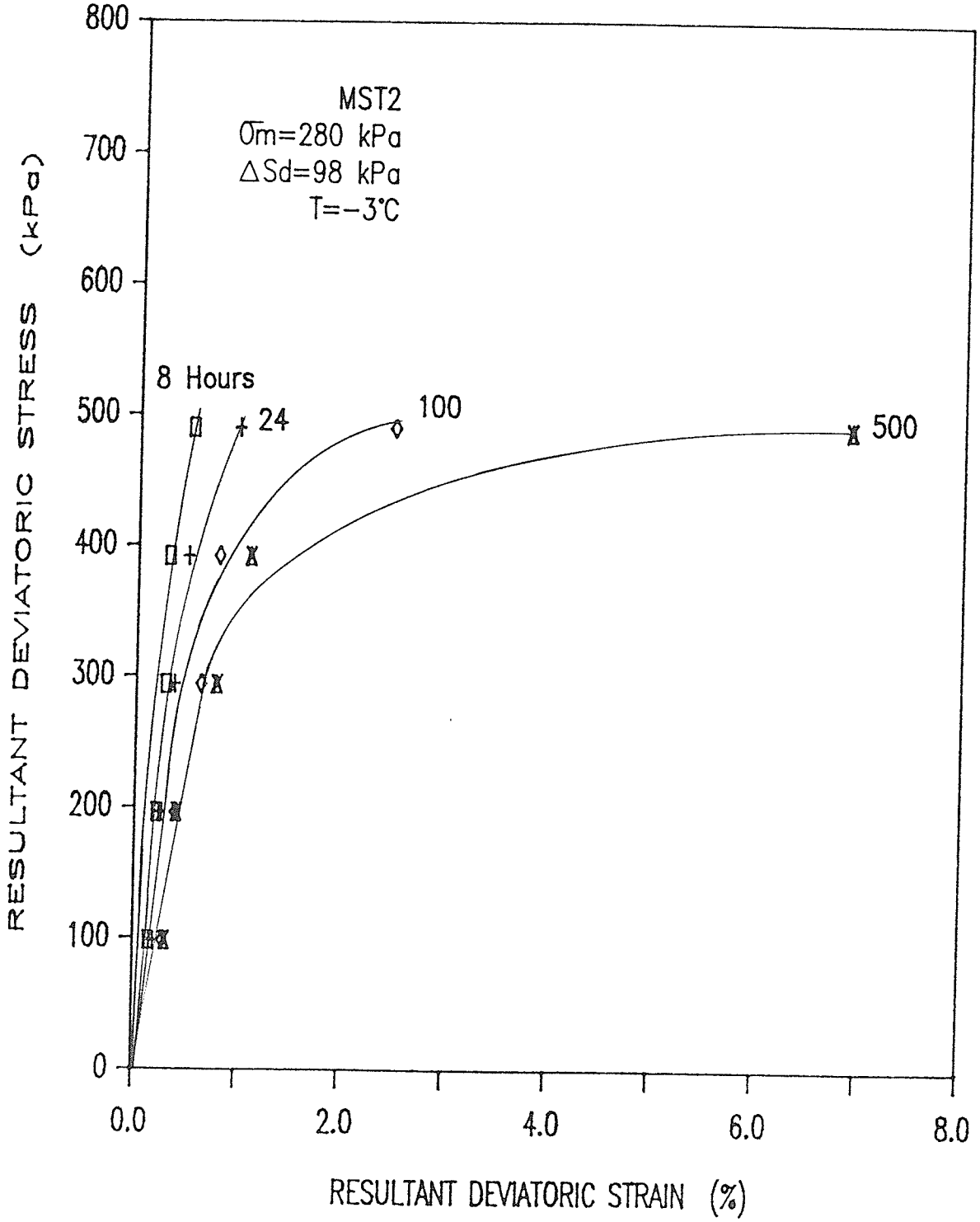


Figure 5.35 Resultant deviatoric stress versus resultant deviatoric strain (MST2)

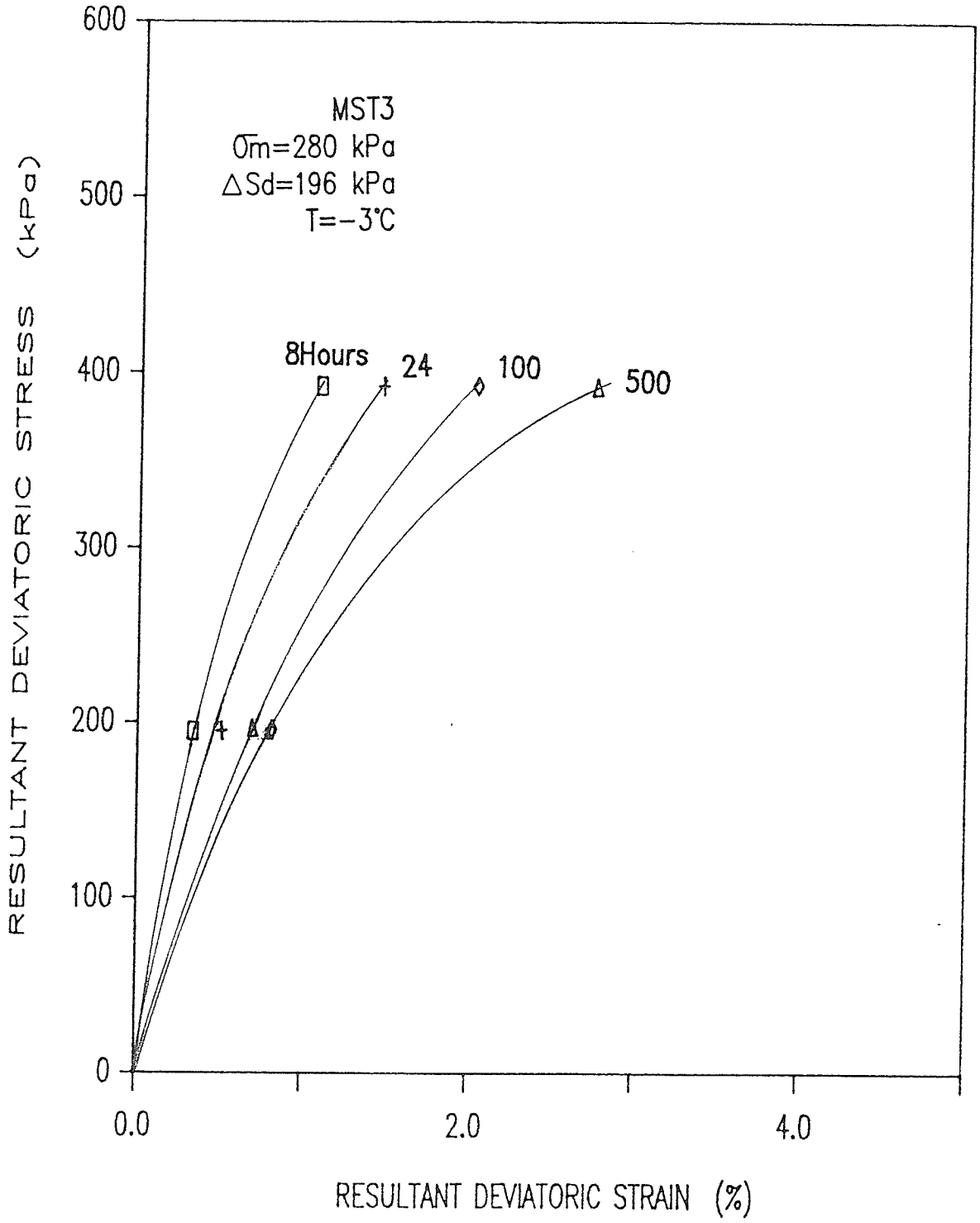


Figure 5.36 Resultant deviatoric stress versus resultant deviatoric strain (MST3)

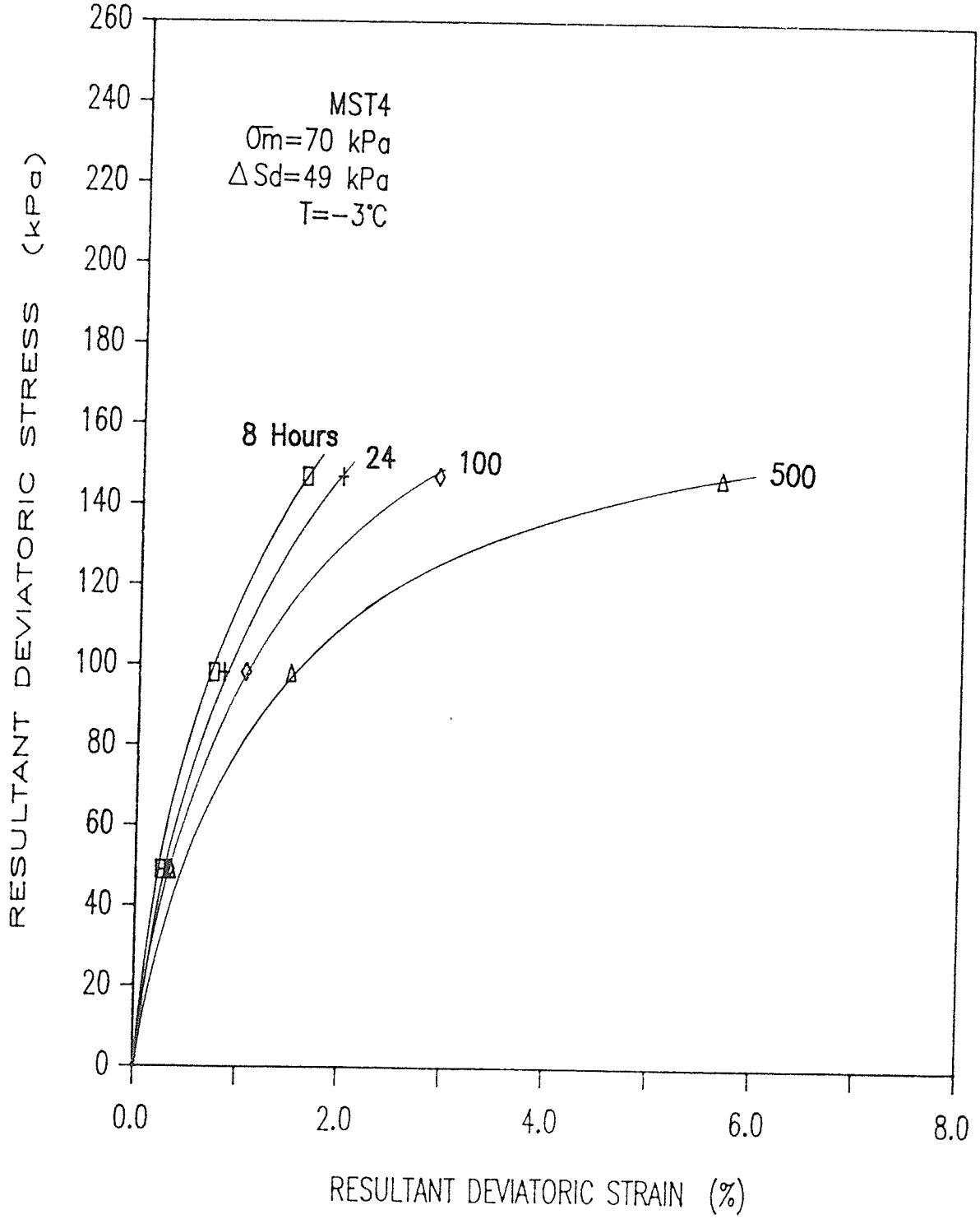


Figure 5.37 Resultant deviatoric stress versus resultant deviatoric strain (MST4)

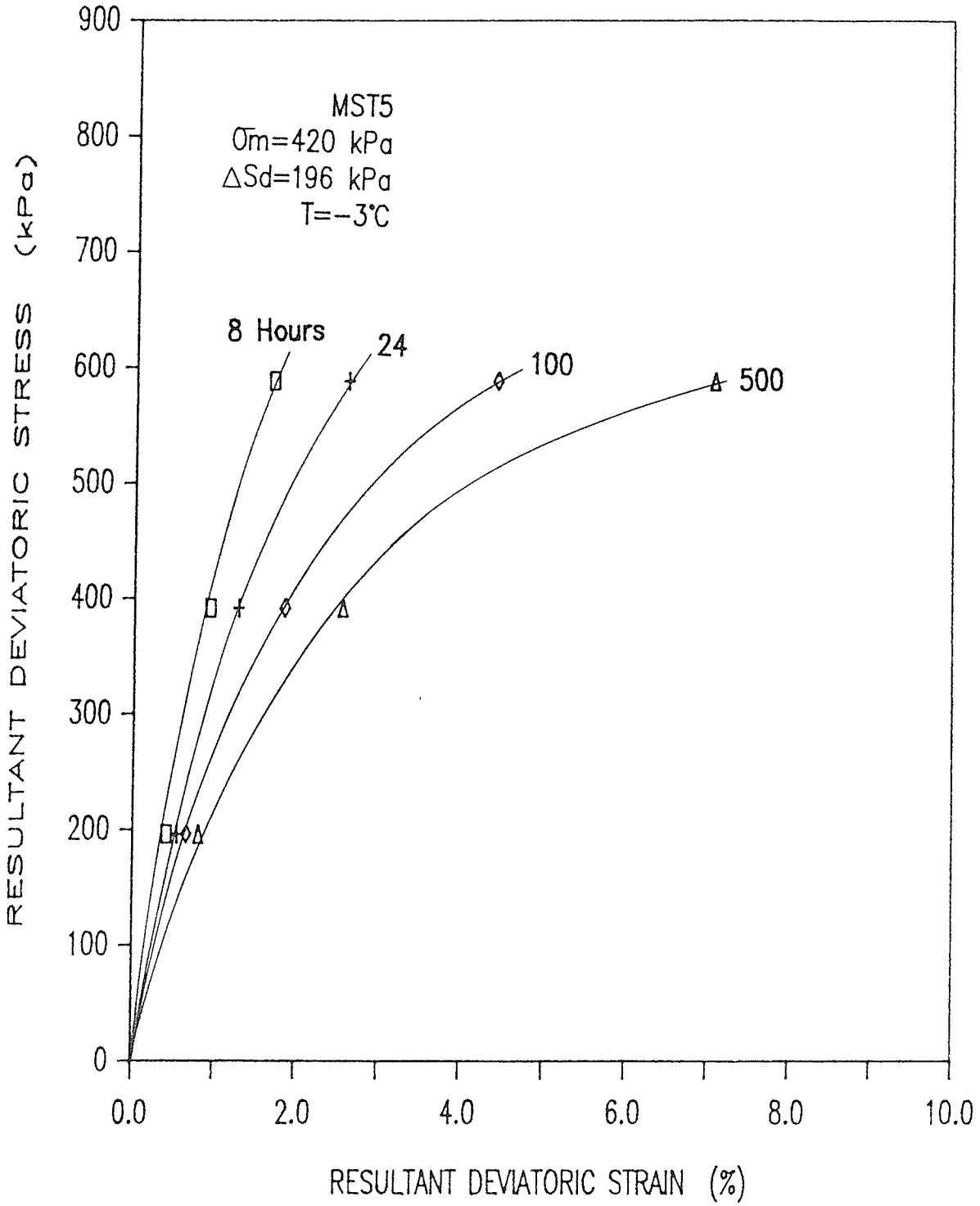


Figure 5.38 Resultant deviatoric stress versus resultant deviatoric strain (MST5)

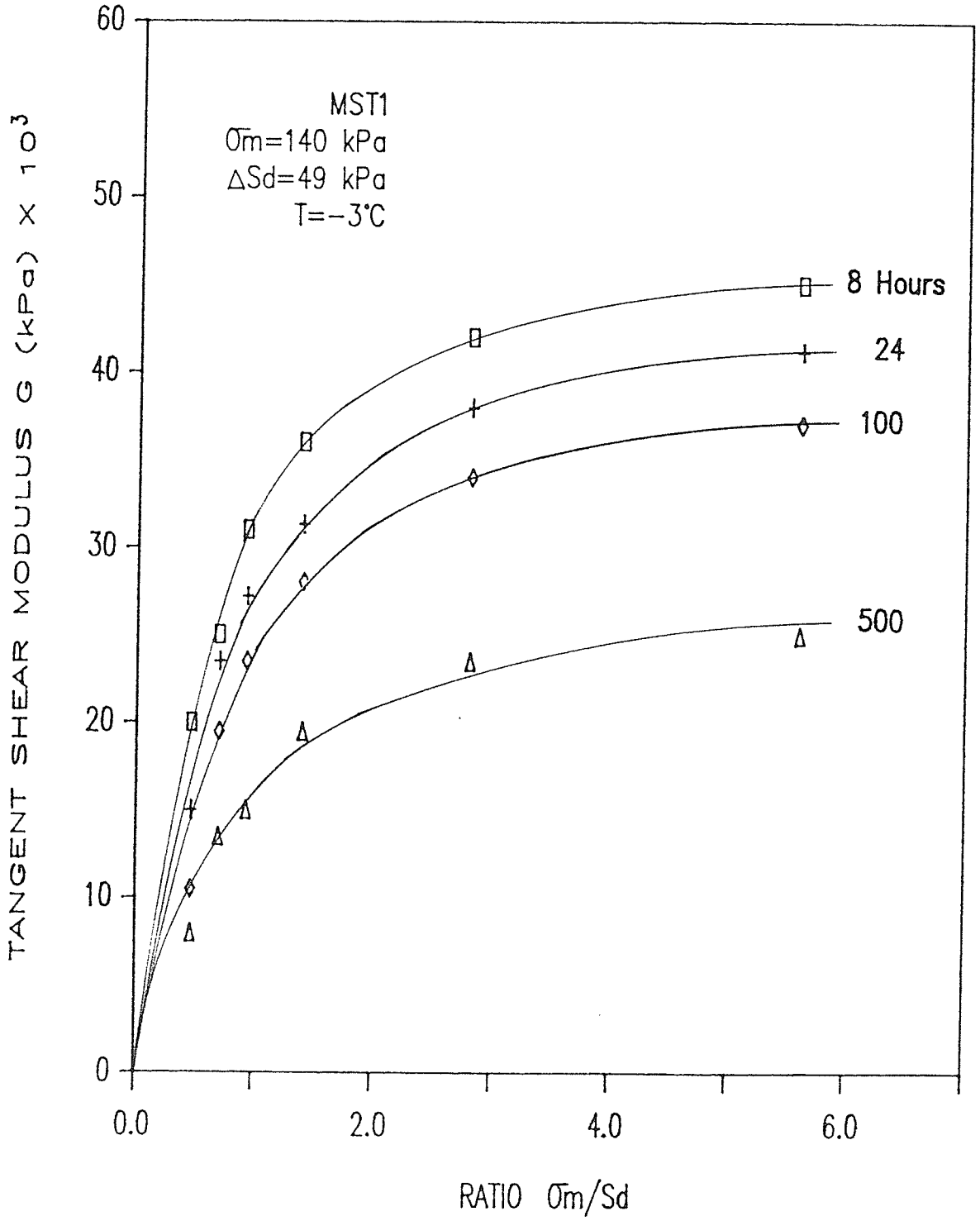


Figure 5.39 Tangent shear modulus versus ratio, $\bar{\sigma}m/\sigma d$ (MST1)

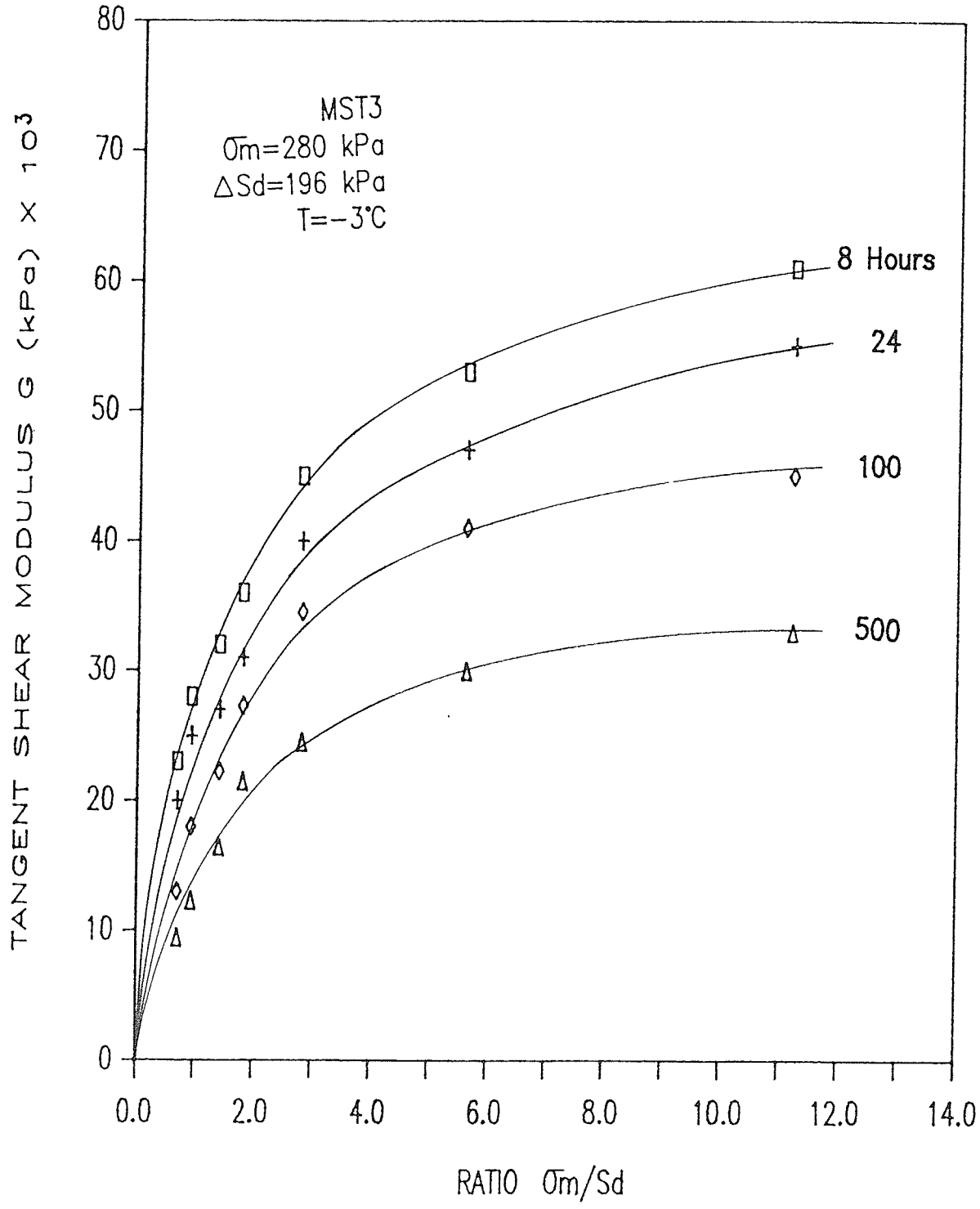


Figure 5.40 Tangent shear modulus versus ratio, σm/Sd (MST3)

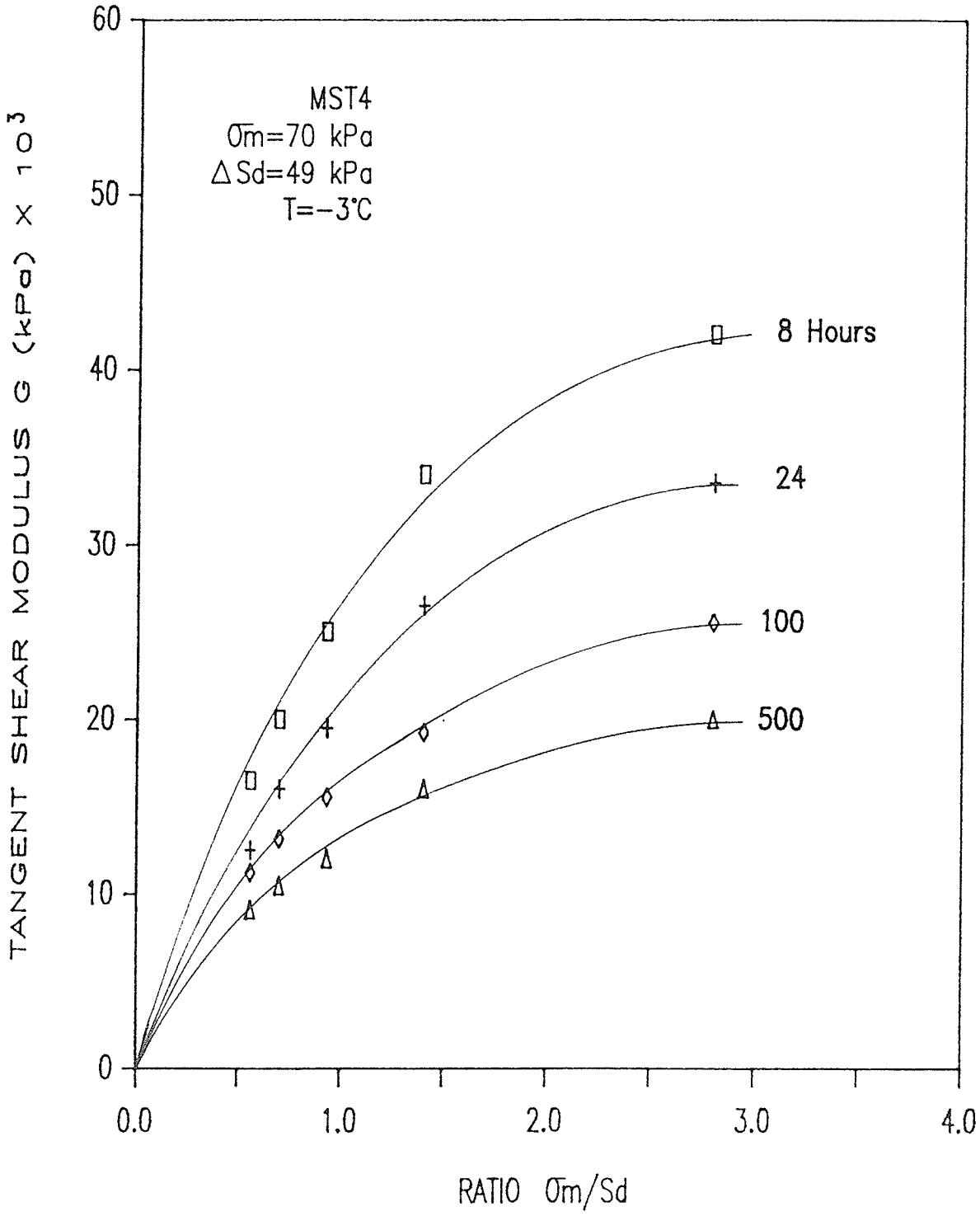


Figure 5.41 Tangent shear modulus versus ratio, $\bar{\sigma}m$/Sd (MST4)

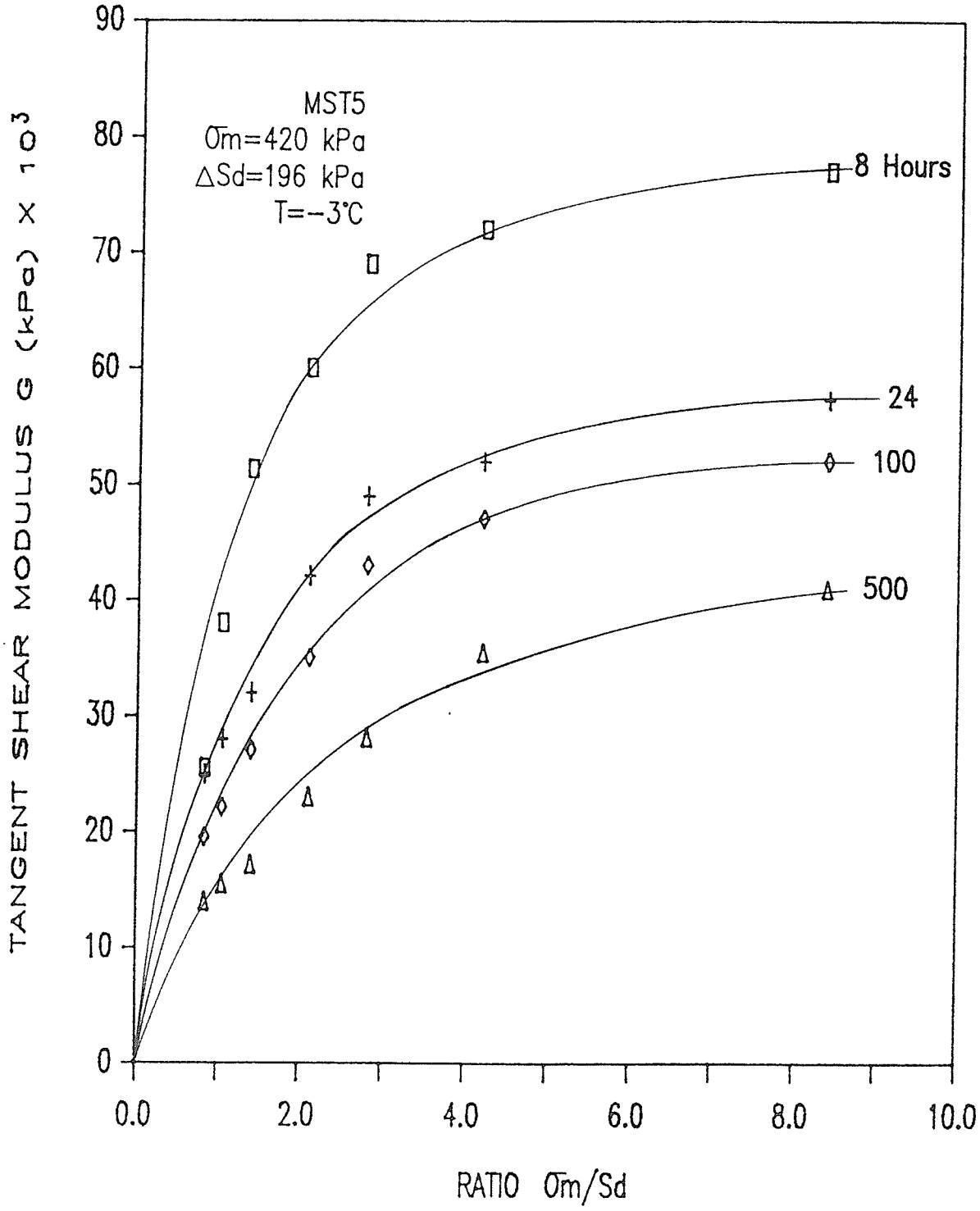


Figure 5.42 Tangent shear modulus versus ratio, Om/Sd (MST5)

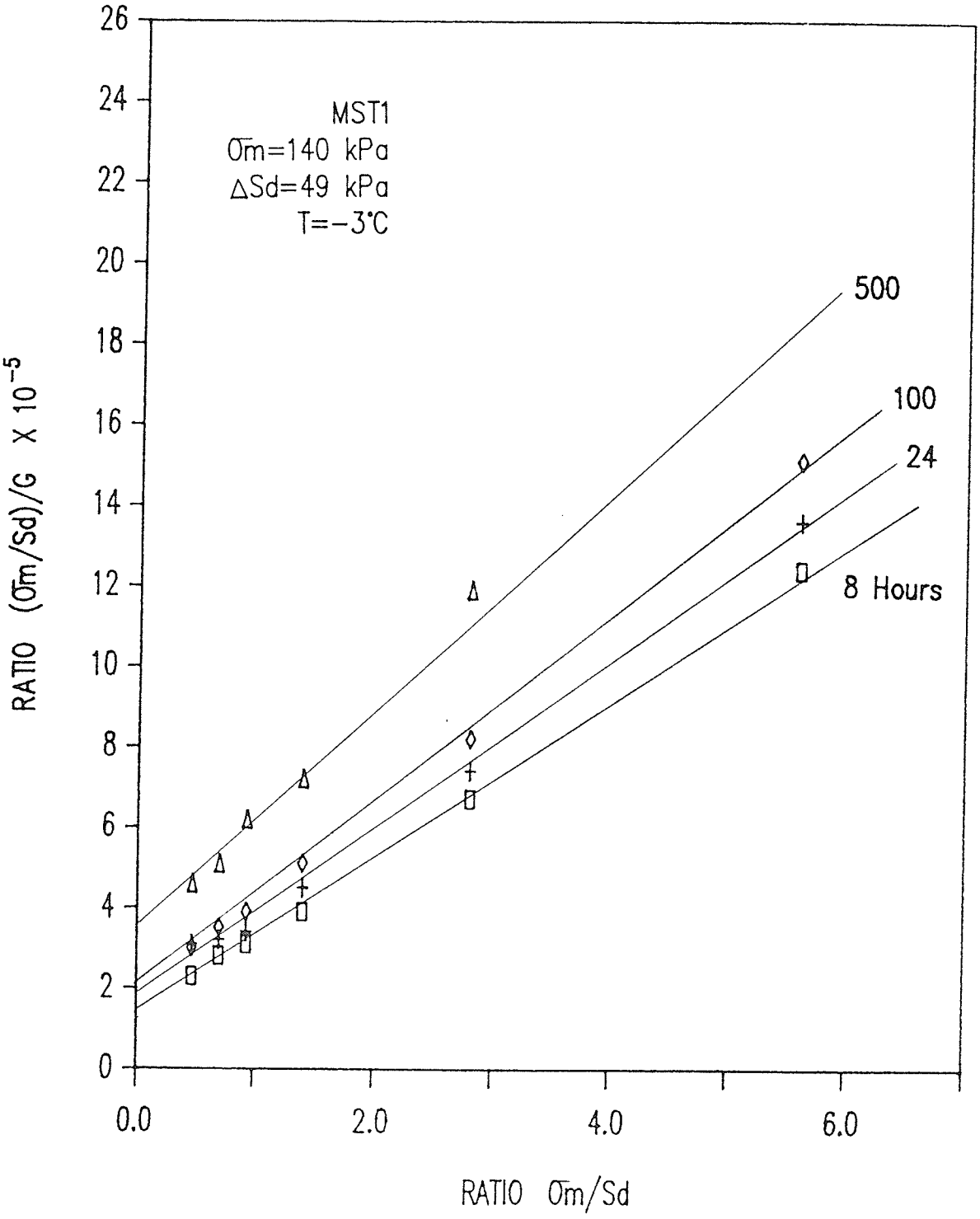


Figure 5.43 Ratio (Om/Sd)/G Versus Om/Sd (MST1)

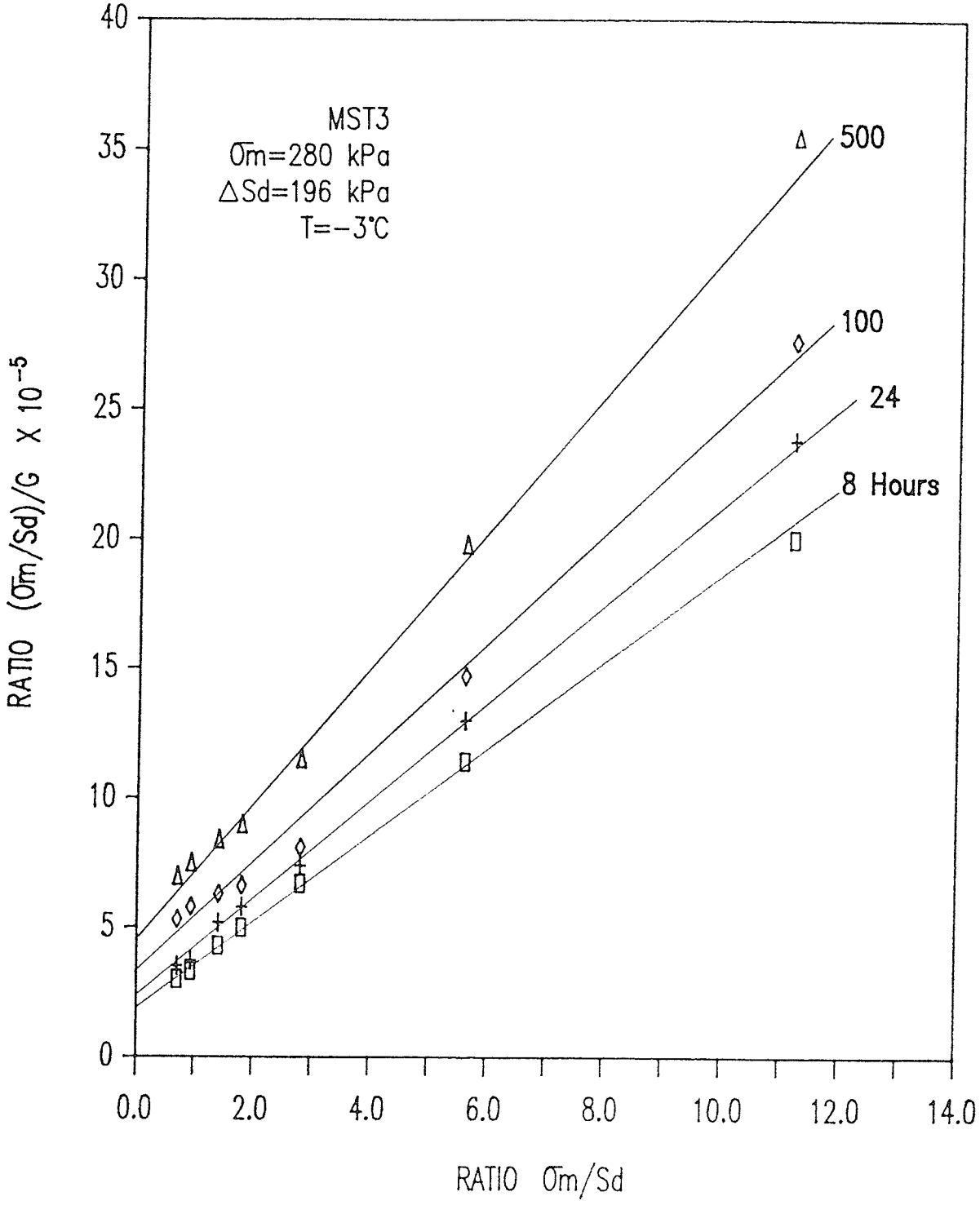


Figure 5.44 Ratio (σm/Sd)/G Versus σm/Sd (MST3)

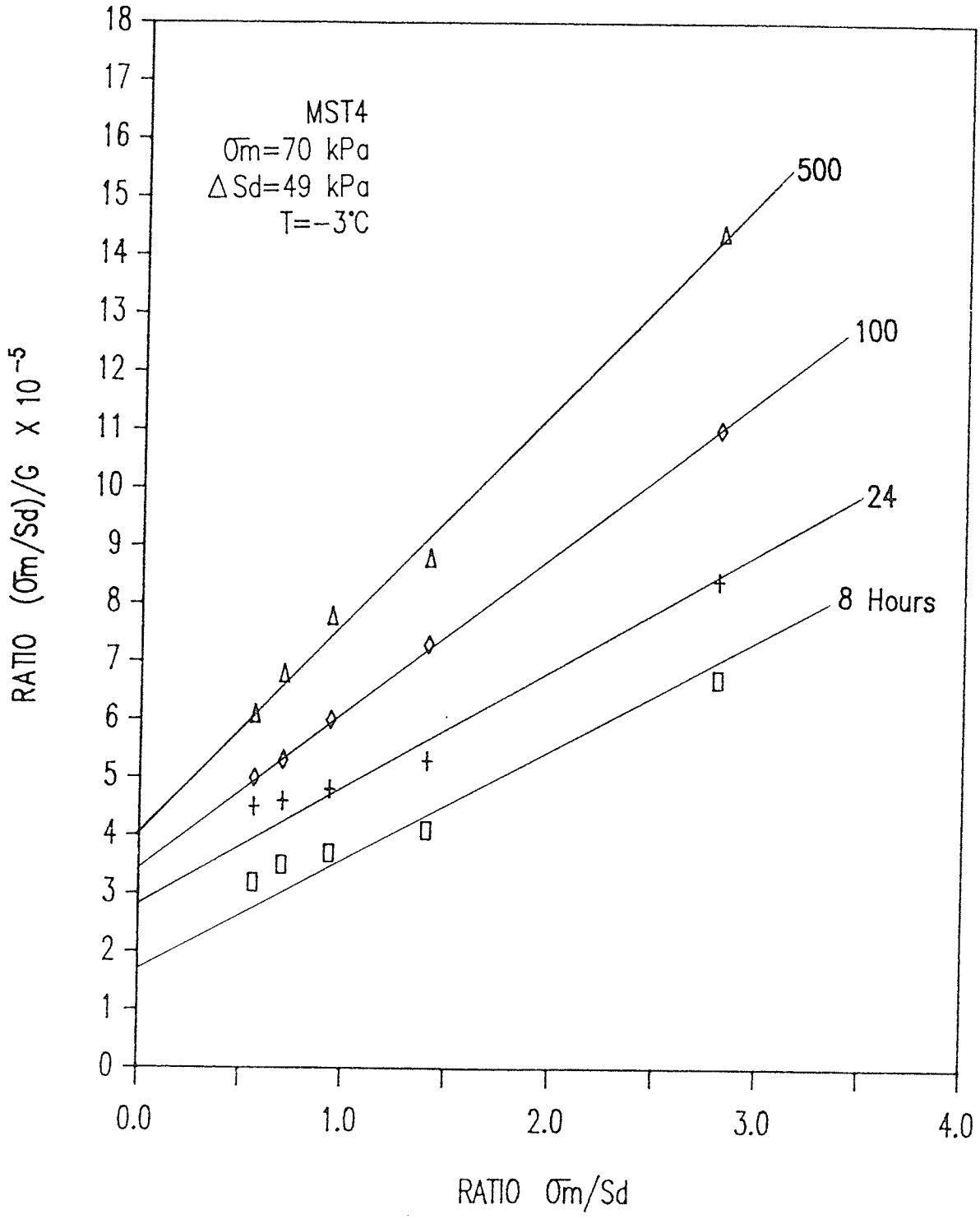


Figure 5.45 Ratio ($\bar{\sigma}m/Sd$)/G Versus $\bar{\sigma}m/Sd$ (MST4)

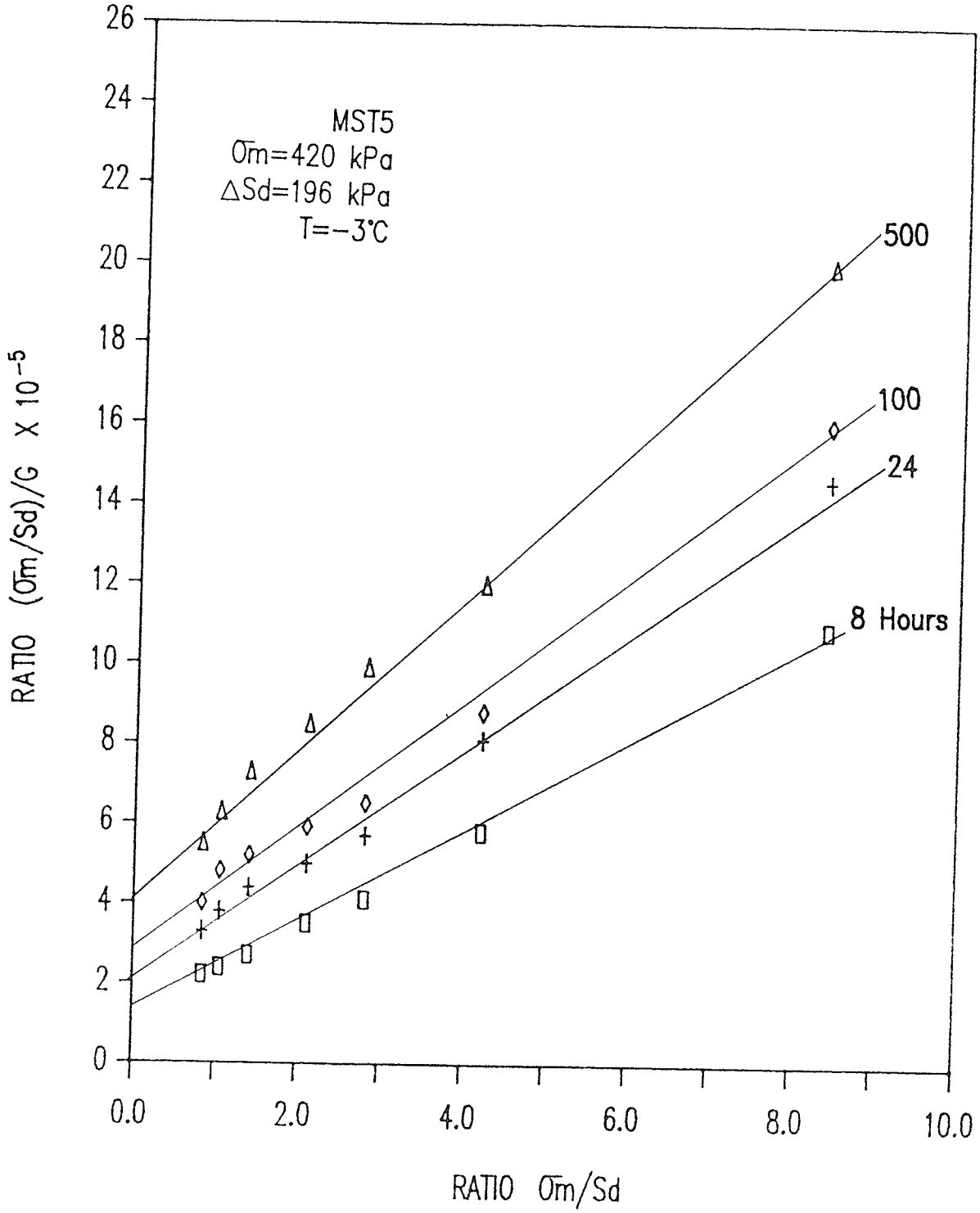


Figure 5.46 Ratio (Om/Sd)/G Versus Om/Sd (MST5)

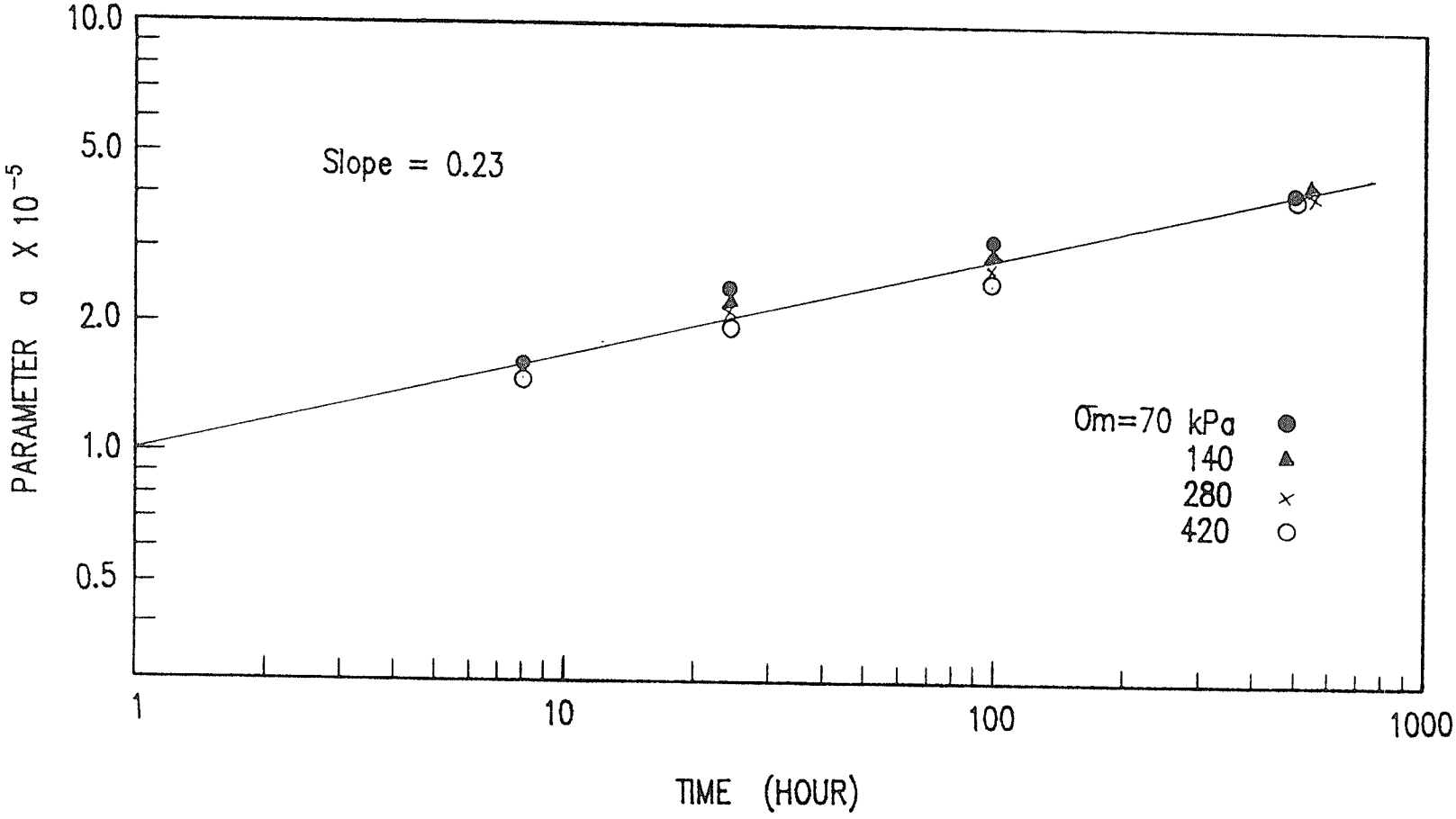


Figure 5.47 Parameter 'a' versus time

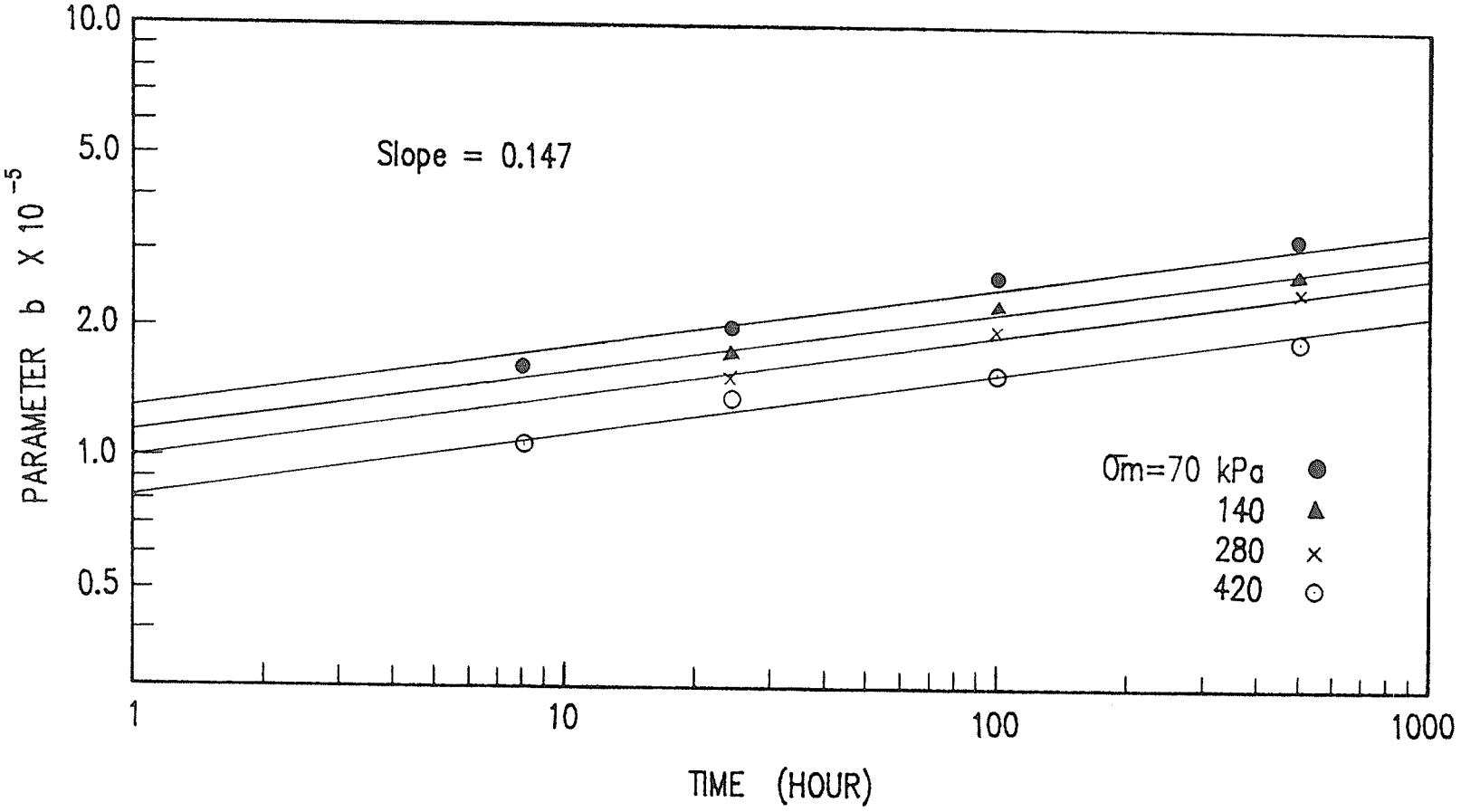


Figure 5.48 Parameter 'b' versus time

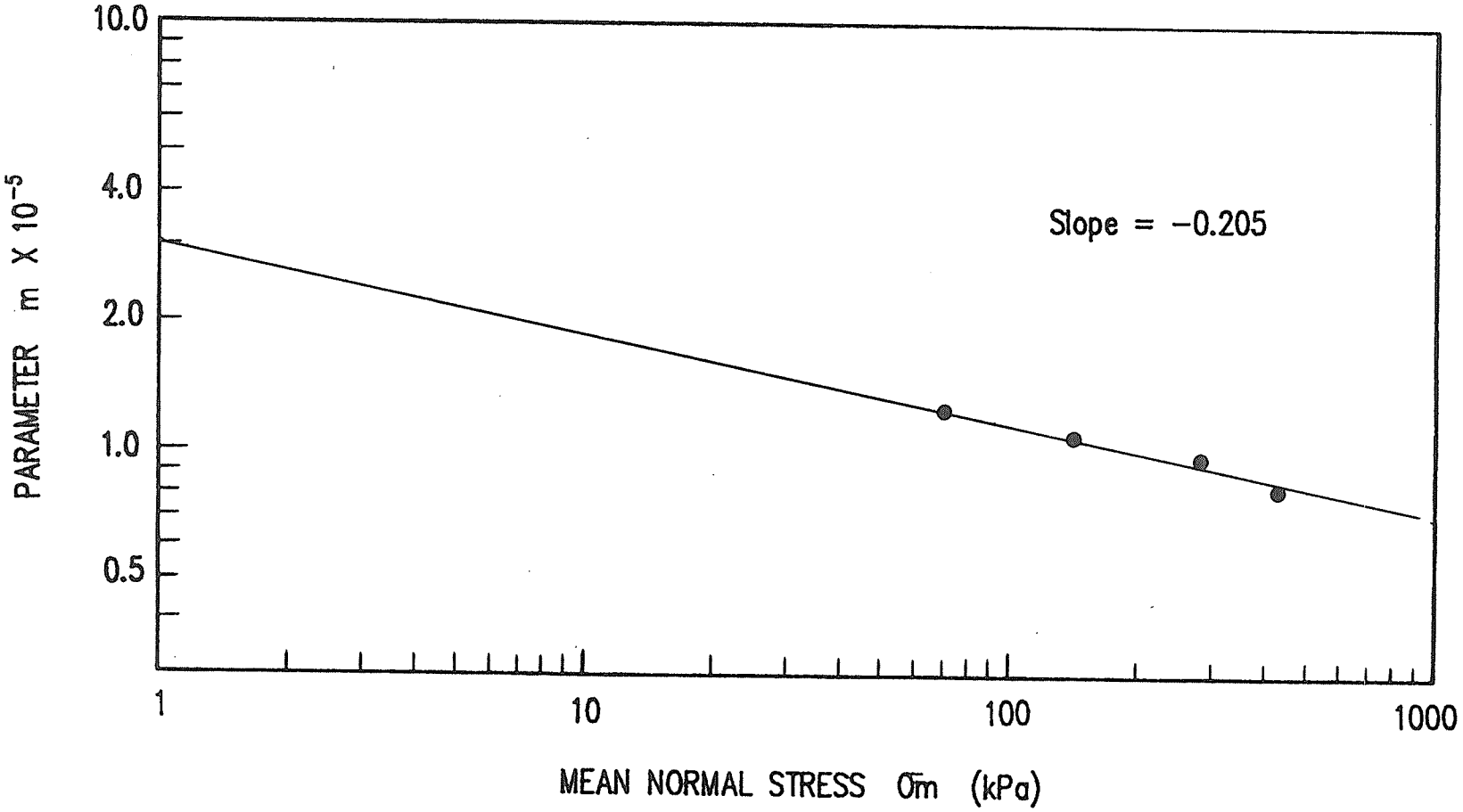


Figure 5.49 Parameter m versus mean normal stress

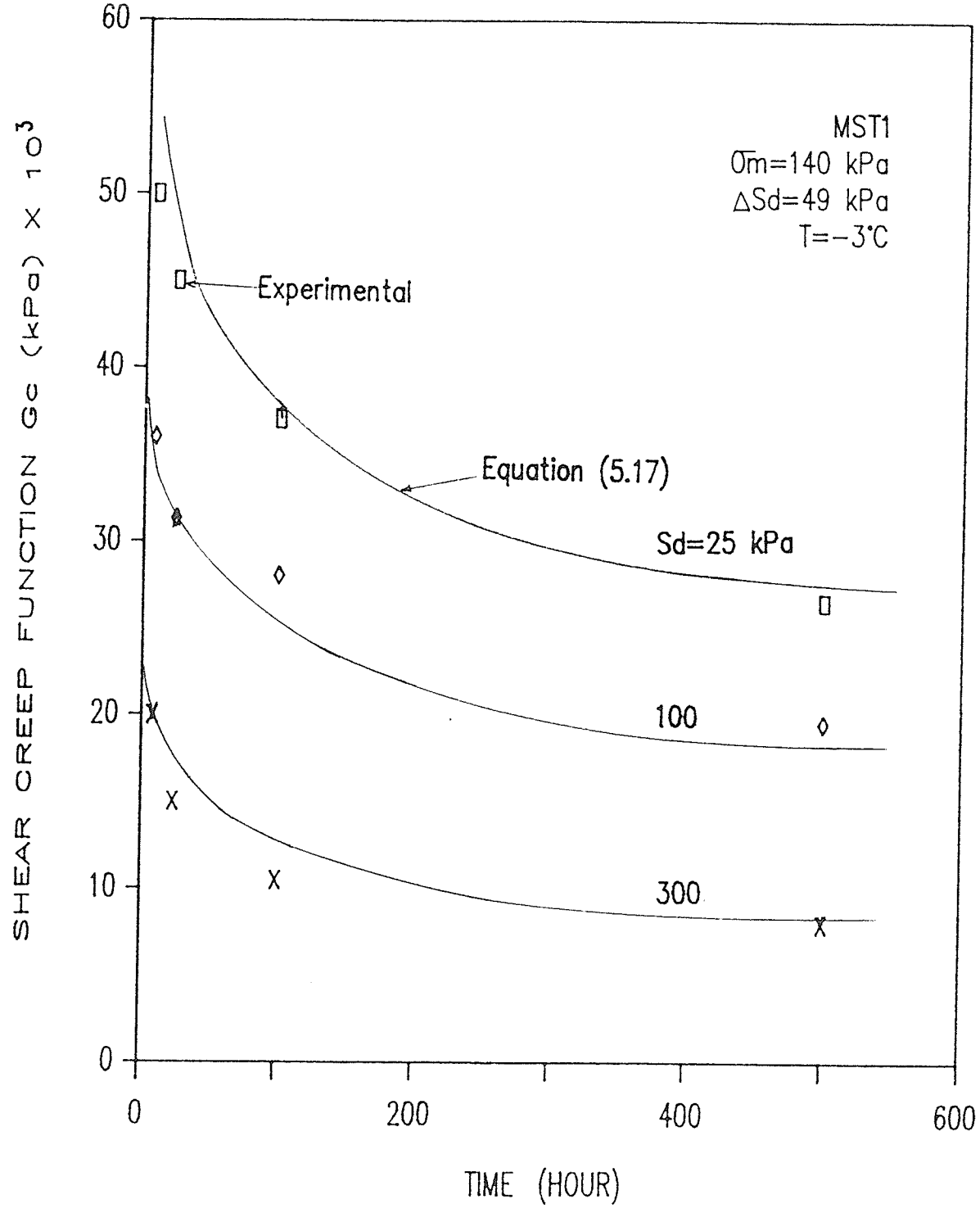


Figure 5.50 Shear creep function versus time (MST1)

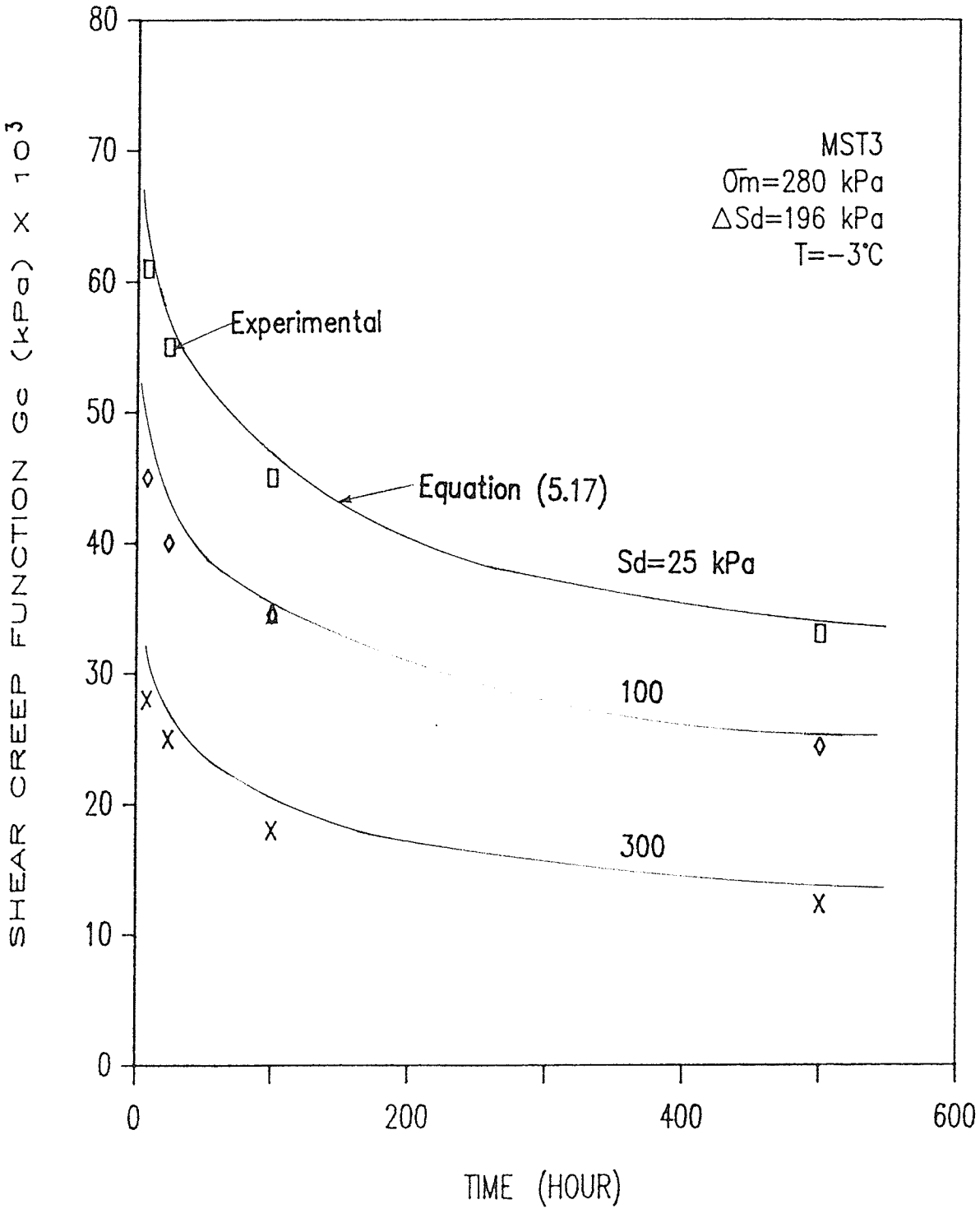


Figure 5.51 Shear creep function versus time (MST3)

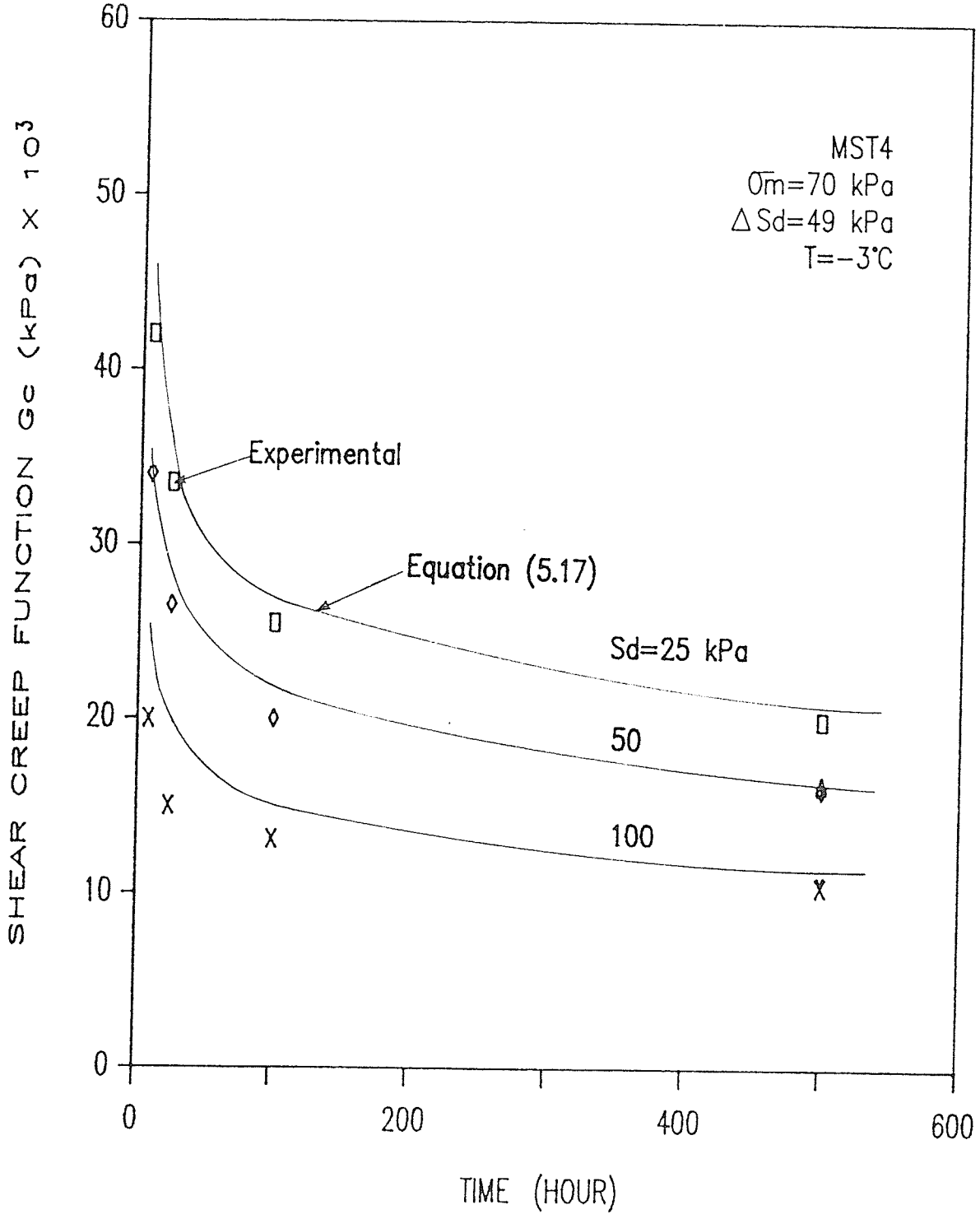


Figure 5.52 Shear creep function versus time (MST4)

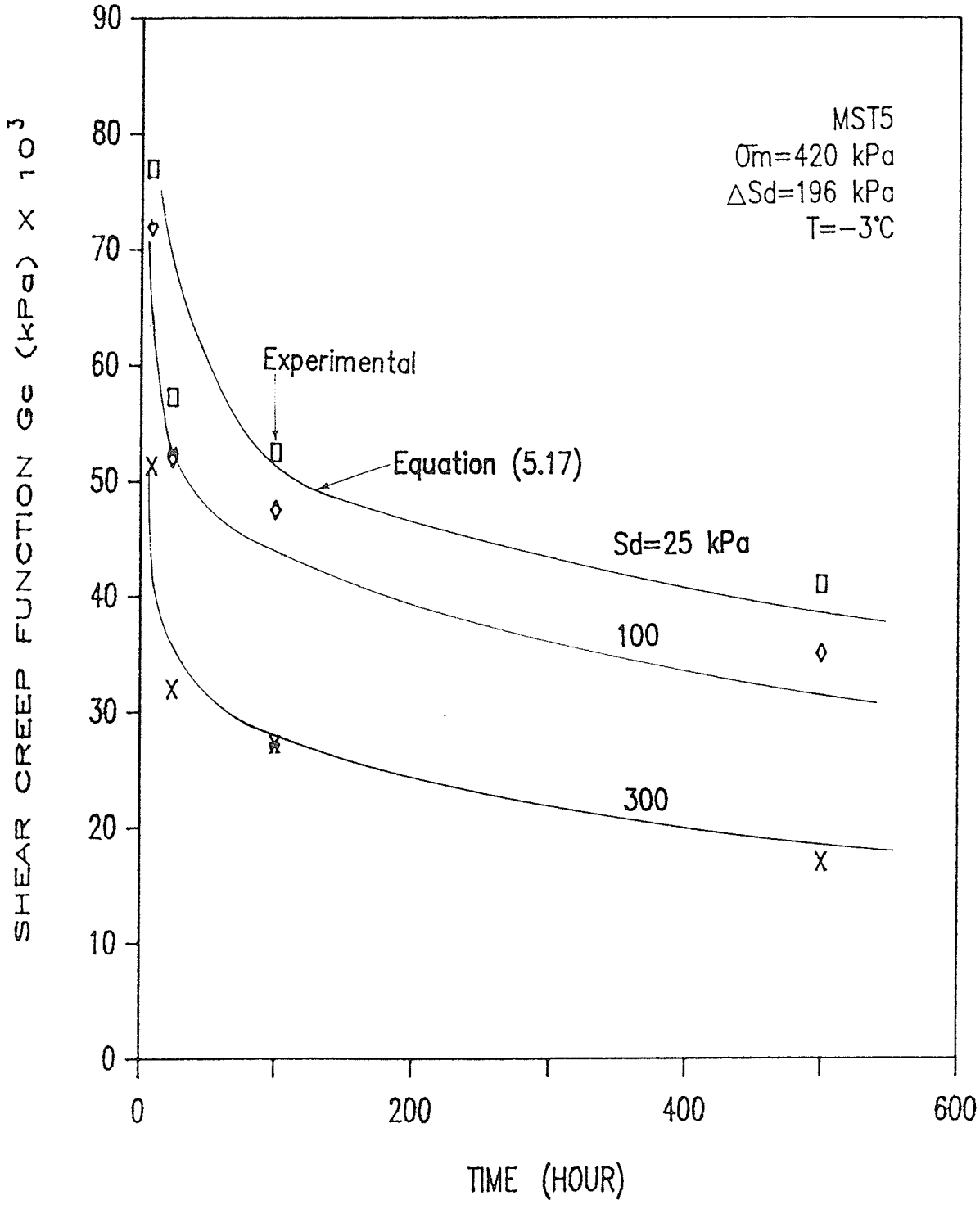


Figure 5.53 Shear creep function versus time (MST5)

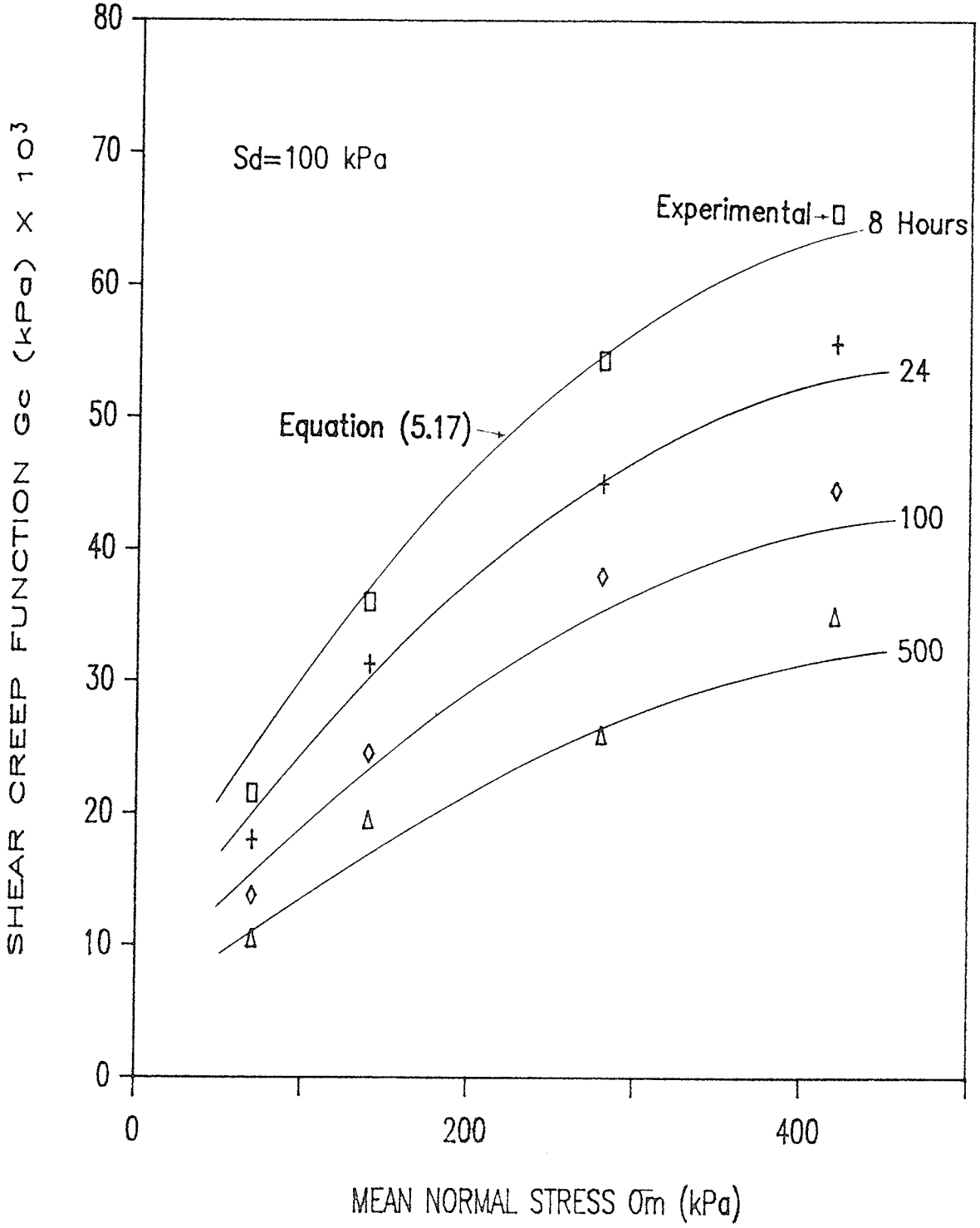


Figure 5.54 Shear creep function versus mean normal stress

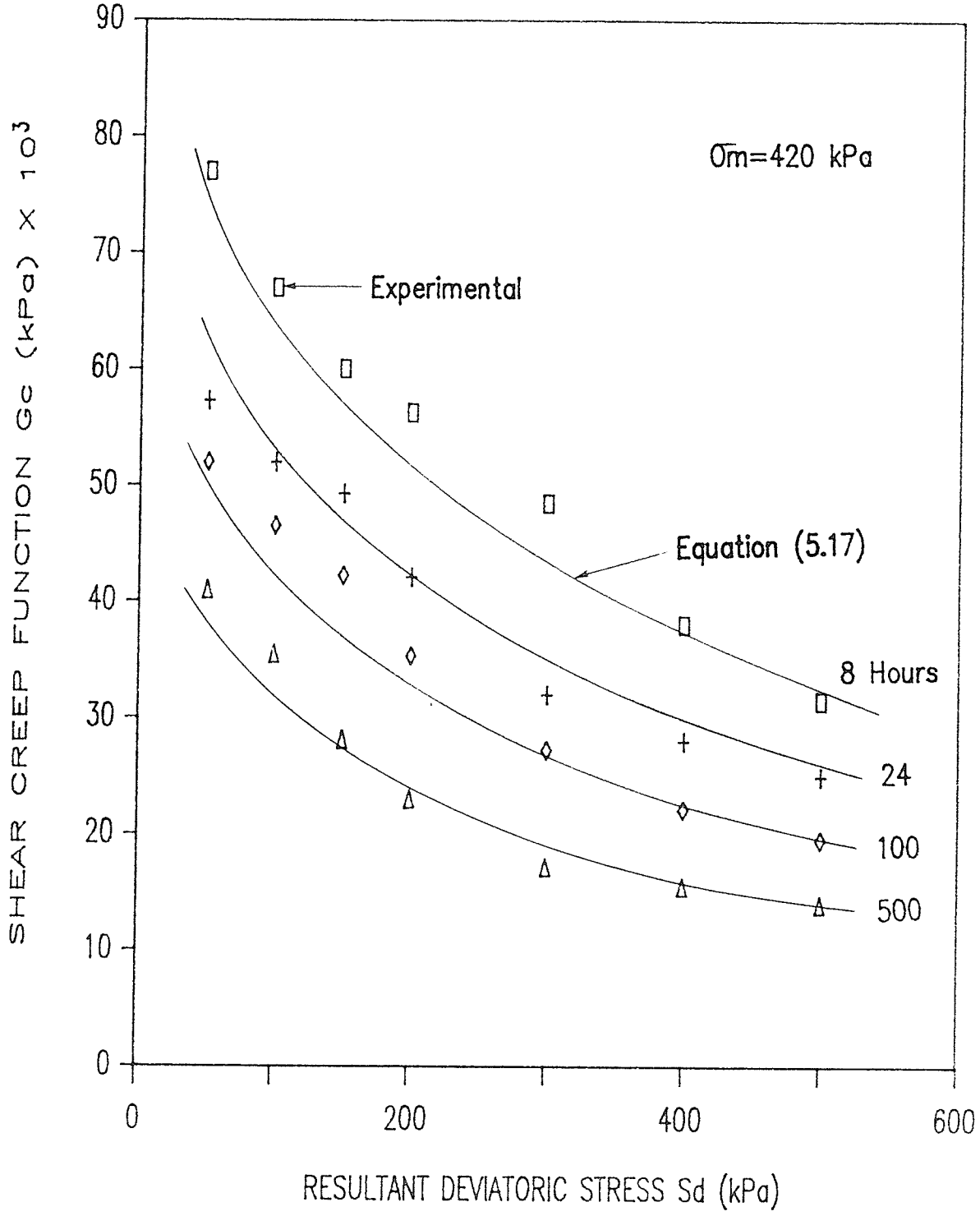


Figure 5.55 Shear creep function versus resultant deviatoric stress

CHAPTER SIX
VERIFICATION OF THE MODELS

CHAPTER 6

VERIFICATION OF THE MODELS

6.1 INTRODUCTION

In preceding Chapters 4 and 5, the models for bulk creep function and shear creep function were developed. The model for bulk creep function was based on isotropic consolidation tests and the model for shear creep function was based on constant mean normal stress triaxial compression tests. The purpose was to develop a constitutive creep equation that could be used to predict deformation under a general stress state. To test the model, four constant cell pressure triaxial compression tests (in which changes in mean normal stress and deviator stress occur simultaneously) were carried out and a comparison was made between the observed deformations, and those calculated on the basis of the model. The basic constitutive creep equation (eqn. 2.37) was used to calculate the axial strain of the sample and this was compared to the measured axial strain. In this chapter the constant cell pressure triaxial tests are described, the results and the comparisons are presented.

6.2 CONSTANT CELL PRESSURE, MULTI-STAGE TRIAXIAL CREEP TESTS

6.2.1 Test Procedure

Four constant cell pressure multi-stage triaxial creep tests, MST10, MST11, MST12 and MST13 were performed. The samples for the tests were prepared according to the procedure described in Section 3.2. The physical properties including dry unit weight, water content, porosity and saturation level of the samples are given in Table 6.1. The samples in all four tests were consolidated under an isotropic stress of 70 kPa. Following consolidation the samples were subjected to shear. The cell pressure was held constant and the axial stress was increased in steps. Details of stress application are given in Tables 6.2 through 6.5. Each stress step was maintained constant until the axial strain attenuated. The axial and volumetric deformations were recorded at frequent intervals and are given in the Appendix.

During the tests there were two breakdowns in the refrigeration system of the cold room for about 5 hours in each case and the temperature rose to almost 0°C. In order to avoid excessive sample deformations at this high temperature, the axial loads were removed during the breakdowns. The deformations were not excessive in any of the samples during the first breakdown because the tests were at the initial stage and the axial loads were small. Test MST11 was dismantled after the first breakdown and the sample was checked for any ice lensing, disintegration and other sample variations which may have been caused by the rise in temperature. The physical examination of the sample indicated no disintegration, segregation or any ice lensing. Therefore, tests MST10 and MST12 were continued further and test MST11 was replaced by test MST13.

6.2.2 Test Results

The true axial and true volumetric strains are shown plotted against cumulative time for test MST10, in Figures 6.1. The deviator stress, $(\sigma_1-\sigma_3)$, for each increment is shown on the plot. The axial strain attenuated at every deviatoric stress step although, it is not very evident from the plots because of the scale. This test was continued for more than 400 days. The first breakdown occurred during stress increment, $(\sigma_1-\sigma_3)$=40 kPa. There was no excessive deformation during this breakdown. The second breakdown occurred during $(\sigma_1-\sigma_2)$=200 kPa. This resulted in a sharp increase in the axial strain and a sharp drop in the volumetric strain. When the sample temperature was restored to -3°C, the axial and volumetric strains continued at rates comparable to those that preceded the breakdown.

The true axial and true volumetric strains versus cumulative time for test MST12, are shown plotted in Figure 6.2. The deviatoric stress for each increment is shown on the plot. The sample underwent attenuating creep during each stress step. The test was conducted simultaneously with test, MST10, and was therefore subjected to the same cold room-temperature variations associated with the breakdown of the refrigeration unit. Sudden changes in axial and volumetric strains accompanied the rapid rise in temperature.

The true axial and true volumetric strains versus cumulative time for test MST13, are shown plotted in Figure 6.3. As before the

deviator stress for each loading step is shown on the plot. There was only one breakdown during this test, because this test was set up after the first breakdown. The breakdown occurred during the stress step of $(\sigma_1-\sigma_3)$=200 kPa. Both the axial and volumetric strain increased sharply during the breakdown. When the sample temperature was restored to -3°C both the axial and volumetric strains continued at rates comparable to those that preceded the breakdown.

6.3 VERIFICATION OF THE MODEL

The creep model based on the bulk creep function and the shear creep function developed in chapters 4 and 5 was applied to the measured axial deformations observed in constant cell pressure triaxial creep tests. Both the deviatoric and mean normal stresses changed at every loading step and therefore the deformations which occurred were the result of simultaneous changes in linear and shear strains. For the triaxial test equation (2.37) can be written as:

$$\sigma_{11} = K_c\, \varepsilon_v + 2G_c\, (\varepsilon_{11} - 1/3\, \varepsilon_v) \qquad (6.1)$$

in which σ_{11} = axial stress

ε_v = volumetric strain

ε_{11} = axial strain

Rearranging equation (6.1), the expression for ε_{11} becomes:

$$\varepsilon_{11} = \frac{1}{2G_c}(\sigma_{11} - K_c\,\varepsilon_v + \frac{2}{3}\,G_c\,\varepsilon_v) \qquad (6.2)$$

Since K_c and G_c are time dependent, solutions can be obtained for ε_{11} as a function of time. However, the solutions developed for K_c (4.12) and G_c (5.17), are for constant stress and variable time. As such they are used to generate strain, as a function of time, for a given stress state. Therefore equation (6.2) is directly applicale to single stage loading. Unfortunately a multi-stage triaxial test was performed to test the constitutive model rather than a series of tests at different stress levels. However, it is possible to make a comparison between predicted and observed axial strains, in an approximate manner at least, by reconstructing strain-time curves for each stress increment, by assuming that for a given stress increment and a given elasped time the total strain is the cumulative sum of all strains that occurred during an equal elapsed time interval for each and every stress increment up to and including the increment under consideration. This is illustrated in Figure 6.4. The cumulative strain at time t due to stress, σ_3, applied as a single step is assumed to be the cumulative sum of the instantaneous and creep strains a_i, a_c, b_i, b_c and c_i, c_c which occurred during an equal elapsed time t under the incremental stresses. This reconstructed strain-time curve can then be compared to one generated by equation (6.2) for the same stress state. This was done for five stress increments of the multi-stage triaxial test MST10. The stress increments chosen were consecutive and were started at a level $(\sigma_1-\sigma_3)$=120 kPa which was large enough to produce significant strains.

The predicted and the reconstructed strain-time curves are shown in Figure 6.5 through 6.9. The agrement between the predicted and reconstructed is quite good considering the scatter that was inherant in all test data and the basic assumption made in reconstructing the strain-time curves. No definite conclusion can be made regarding the predictive reliability of the constitutive creep model but, on the basis of the comparison made, it can be said that the model shows some promise.

As another test of the predictive accuracy of the model, the cumulative attenuated axial strains, at the end of each stress increment, during each constant cell pressure triaxial compression test, were compared to those computed using equation (6.2) in conjunction with the attenuated values of K_c and G_c. The computed and observed attenuted axial strains for the three constant cell pressure triaxial compression tests are shown plotted against deviatoric stress, $(\sigma_1-\sigma_3)$, in Figures 6.10 through 6.12. It was observed in Figure 6.10 that in test, MST10, the observed axial strains were lower at low deviatoric stresses but higher at higher deviatoric stresses than the predicted values of the axial strains. In tests, MST12 and MST13, as observed in Figures 6.11 and 6.12, the predicted axial strains were slightly lower than those of the observed values at all stress levels. At higher deviatoric stresses the differences between the predicted and the observed values of axial strains tended to diminish in all the tests. The observed axial strains are plotted against predicted axial axial strains in Figure 6.13. The correlation coefficient was found to be 0.85.

The comparisons indicate that the creep constitutive equation developed by separating isotropic and deviatoric components of stress provided reasonably good agreement between predicted and observed strains when applied to triaxial test results in which isotropic and deviatoric components of stress were increased simultaneously.

TABLE 6.1

Physical Properties of Frozen Sand Sample

Sample	Dry Unit Weight (KN/m^3)	Water Content (%)	Porosity (%)	Water Saturation (%)	Sample Test Temp. (^oC)
MST10	16.0	25.1	42.5	92.0	-3
MST11	15.2	23.1	40.5	91.5	-3
MST12	15.1	24.2	41.3	90.3	-3
MST13	15.3	23.5	42.0	91.7	-3

TABLE 6.2

Details of Stress Application

Test MST10 σ_3=70 kPa

$(\sigma_1 - \sigma_3)$ (kPa)	S_a (kPa)	σ_m (kPa)	Duration of Stress Application (Hour)
0	0.0	70.0	407
20	16.3	76.7	226
40	32.7	83.3	503
60	49.0	90.0	117
80	65.3	96.7	144
100	81.6	103.3	144
120	98.0	110.0	312
140	114.3	116.7	503
160	130.6	123.3	1549
180	147.0	130.0	720
200	163.3	136.7	1223
240	195.9	150.0	719
280	228.6	163.3	807
320	261.3	176.7	1319
360	294.0	190.0	959
400	326.6	203.3	240

TABLE 6.3

Details of Stress Application

Test MST11 σ_3=70 kPa

$(\sigma_1 - \sigma_3)$ (kPa)	S_d (kPa)	σ_m (kPa)	Duration of Stress Application (Hour)
0	0.0	70.0	407
20	16.3	76.7	226
40	32.7	83.3	439

TABLE 6.4

Details of Stress Application

Test MST12 σ_3=70 kPa

$(\sigma_1 - \sigma_3)$ (kPa)	S_d (kPa)	σ_m (kPa)	Duration of Stress Application (Hour)
0	0.0	70.0	407
20	16.3	76.7	226
40	32.7	83.3	503
60	49.0	90.0	117
80	65.3	96.7	144
100	81.6	103.3	144
120	98.0	110.0	312
140	114.3	116.7	167
160	130.6	123.3	359
180	147.0	130.0	506
200	163.3	136.7	1749
220	179.6	143.3	1293
240	195.9	150.0	719
280	228.6	163.3	807
320	261.3	176.7	1319
360	294.0	190.0	959
400	326.6	203.3	240

TABLE 6.5

Details of Stress Application

Test MST13 σ_3=70 kPa

$(\sigma_1 - \sigma_3)$ (kPa)	S_a (kPa)	σ_m (kPa)	Duration of Stress Application (Hour)
0	0.0	70.0	335
80	65.3	96.7	312
100	81.6	103.3	167
120	98.0	110.0	335
140	114.3	116.7	503
160	130.6	123.3	1082
180	147.0	130.0	720
200	163.3	136.7	1223
240	195.9	150.0	719
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320	261.3	176.7	1319
400	326.6	203.3	959
480	391.9	230.0	240

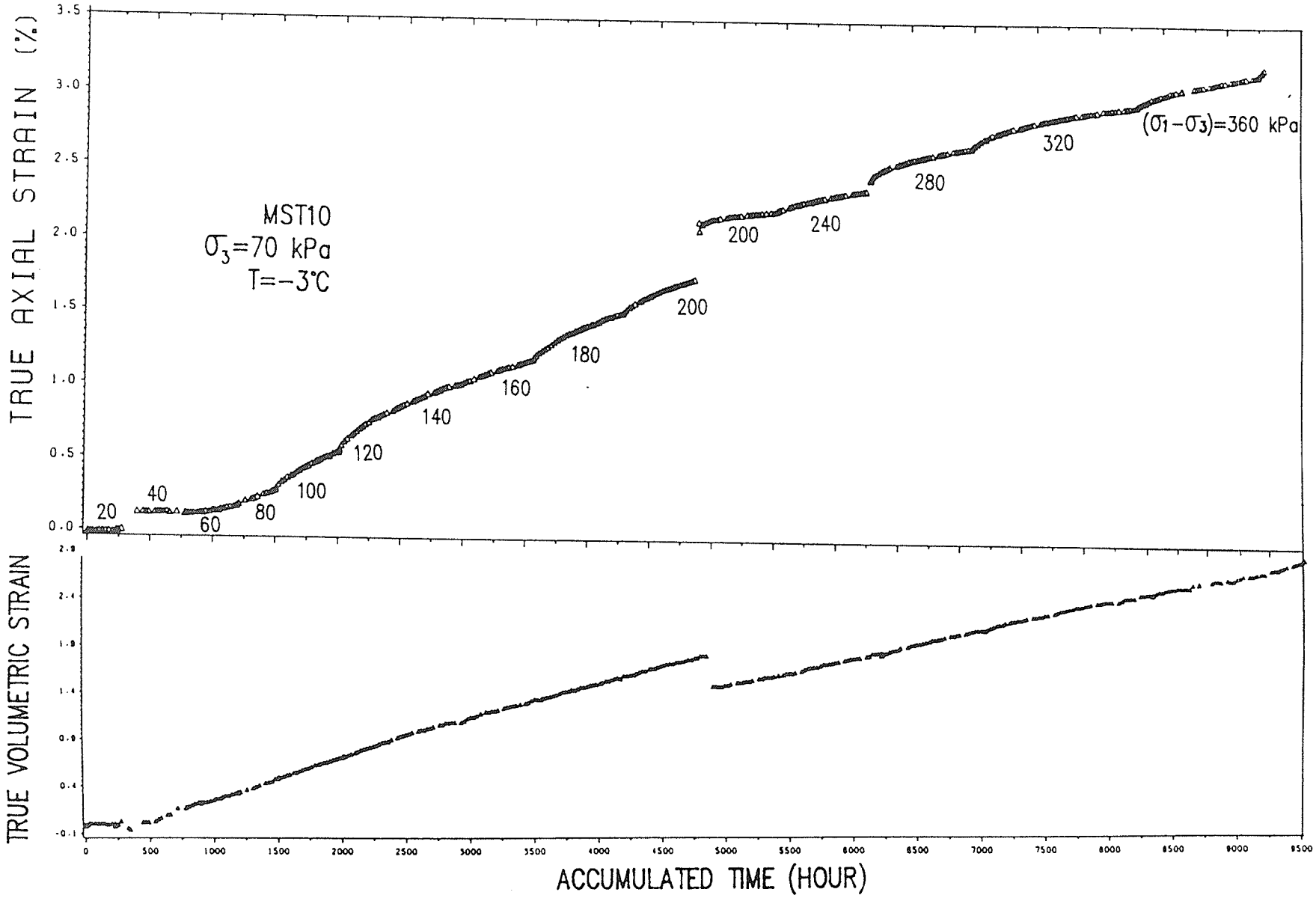

Figure 6.1 True volumetric and true axial strain versus accumulated time (MST10)

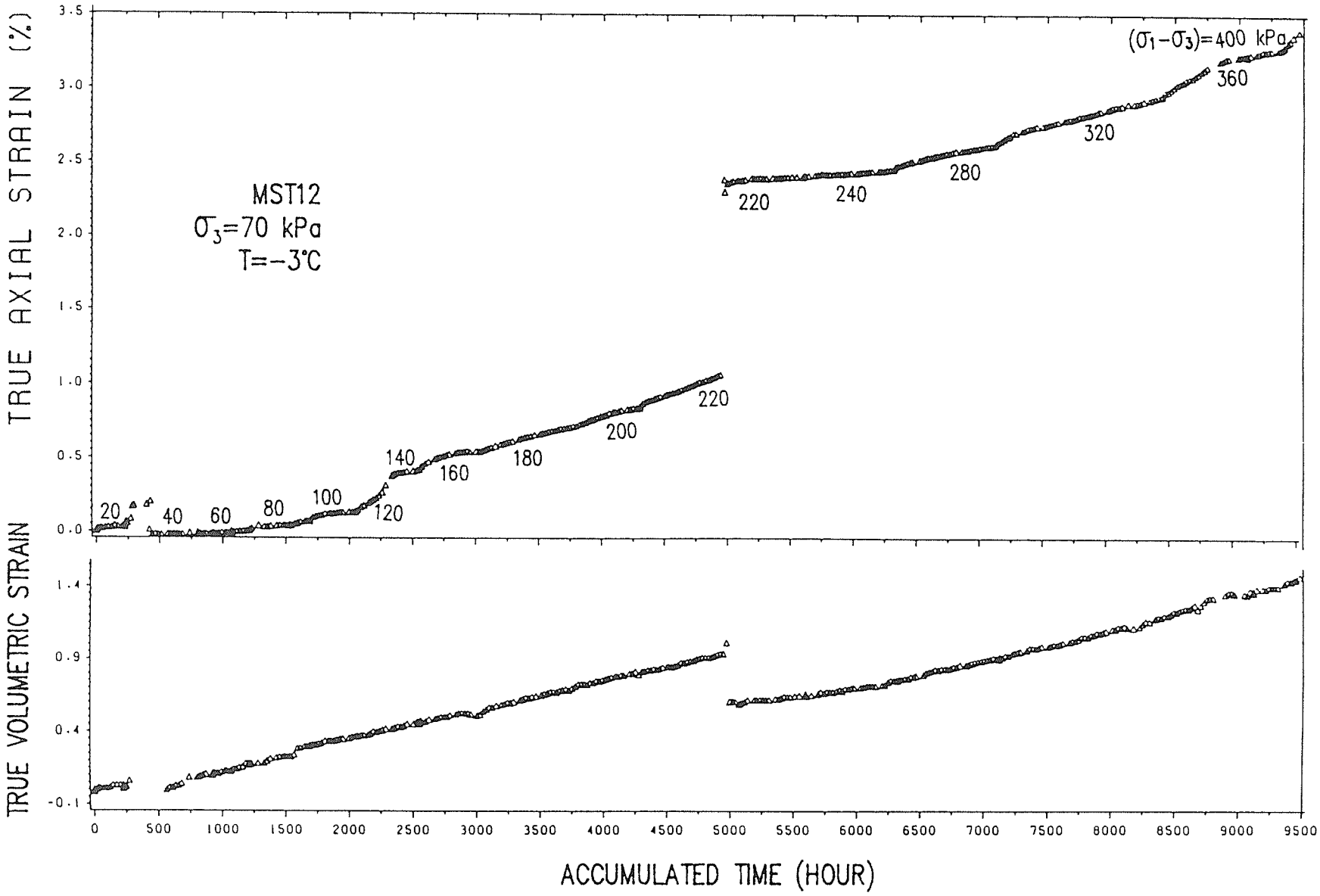

Figure 6.2 True volumetric and true axial strain versus accumulated time (MST12)

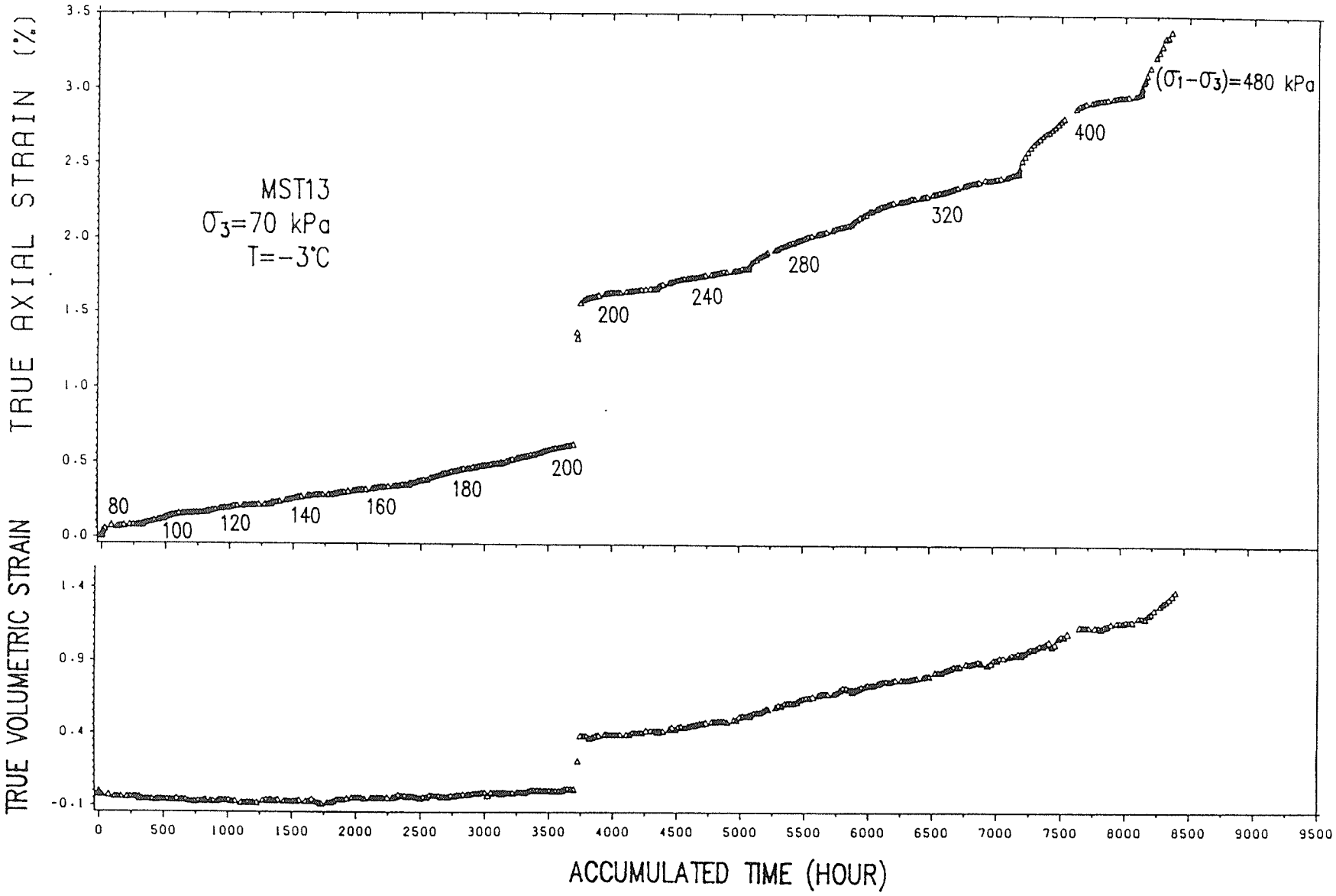

Figure 6.3 True volumetric and true axial strain versus accumulated time (MST13)

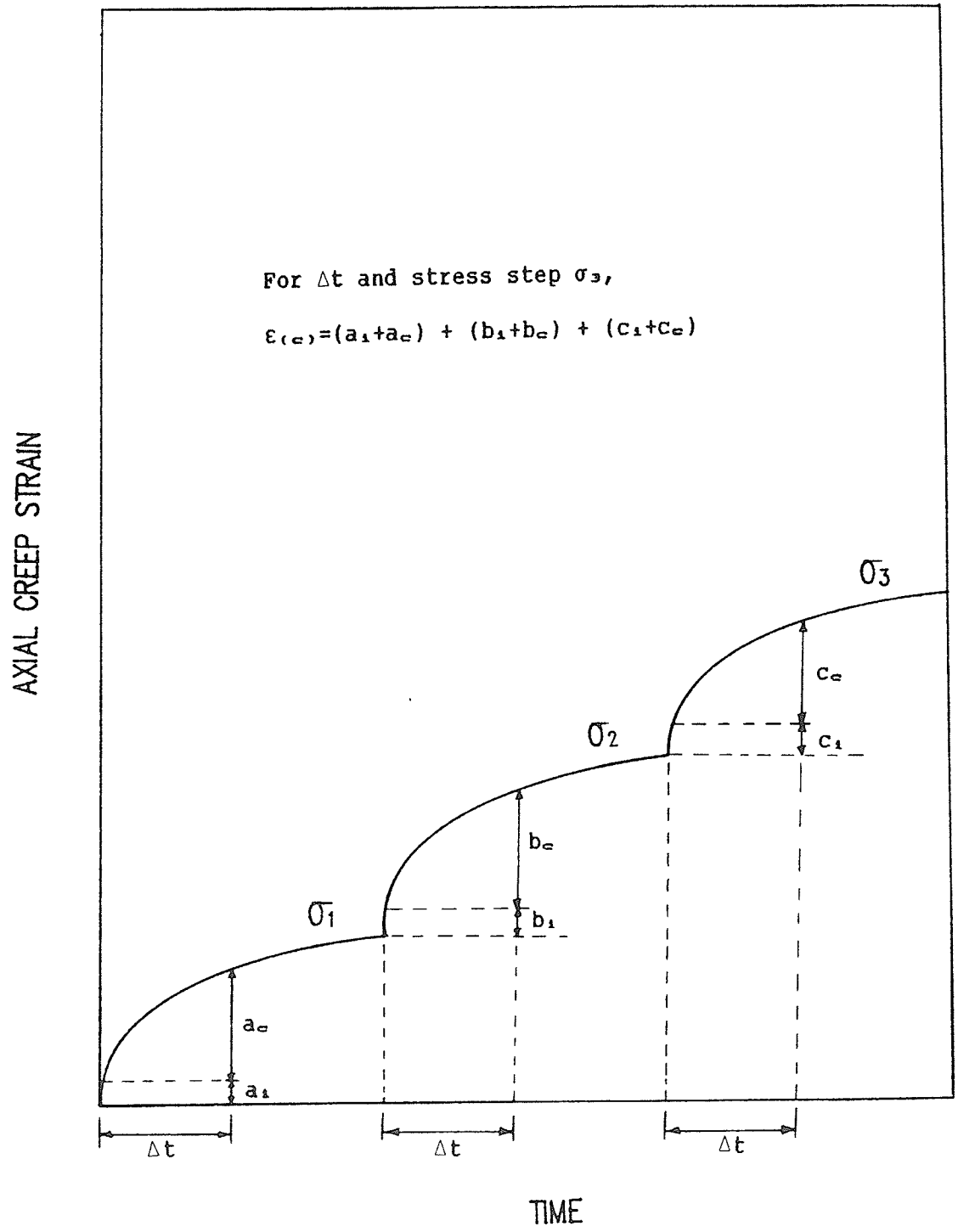

Figure 6.4 Axial creep strain versus time in a multi-stage test

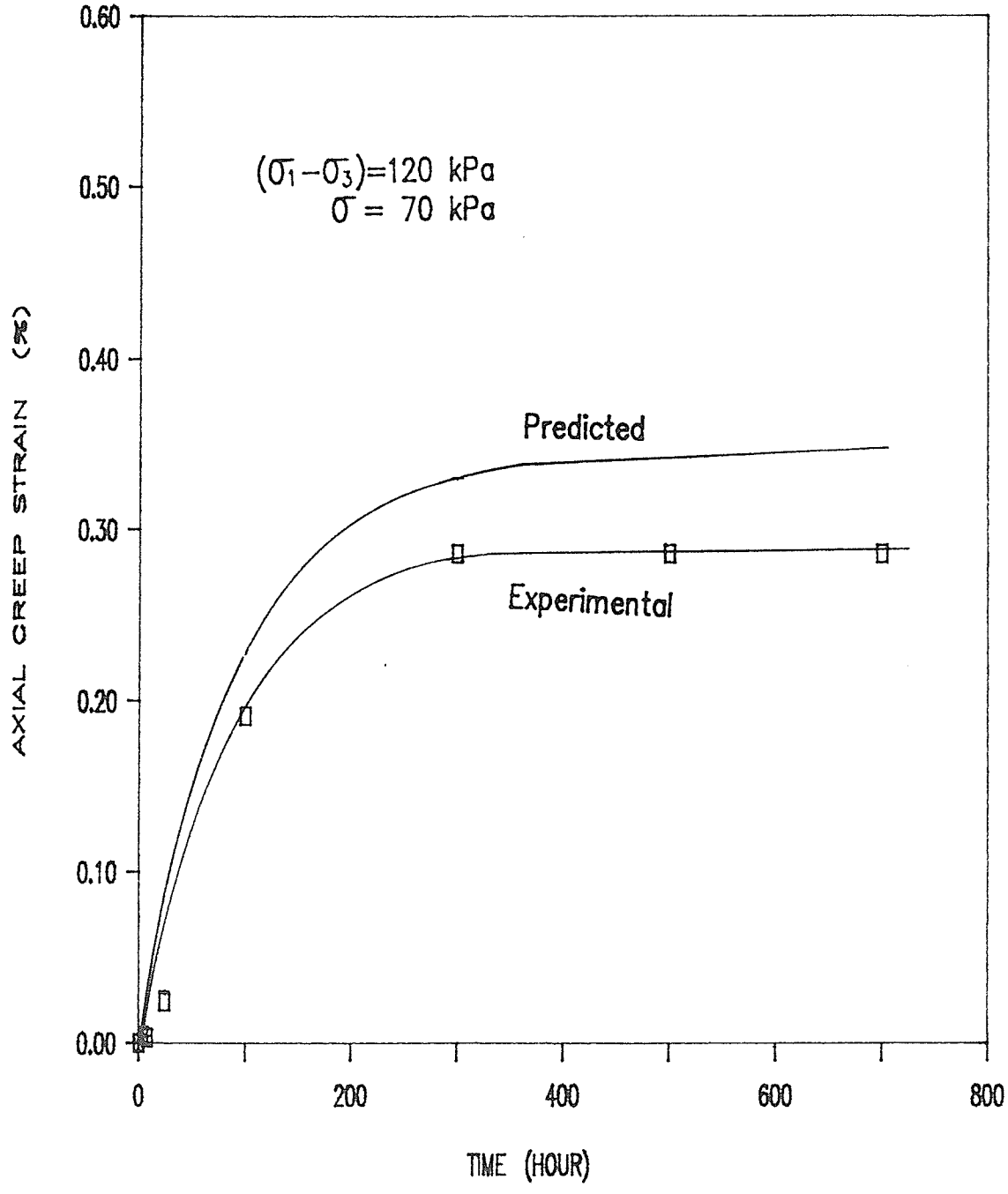

Figure 6.5 Axial creep strain versus time $(\sigma_1-\sigma_3)$=120 kPa

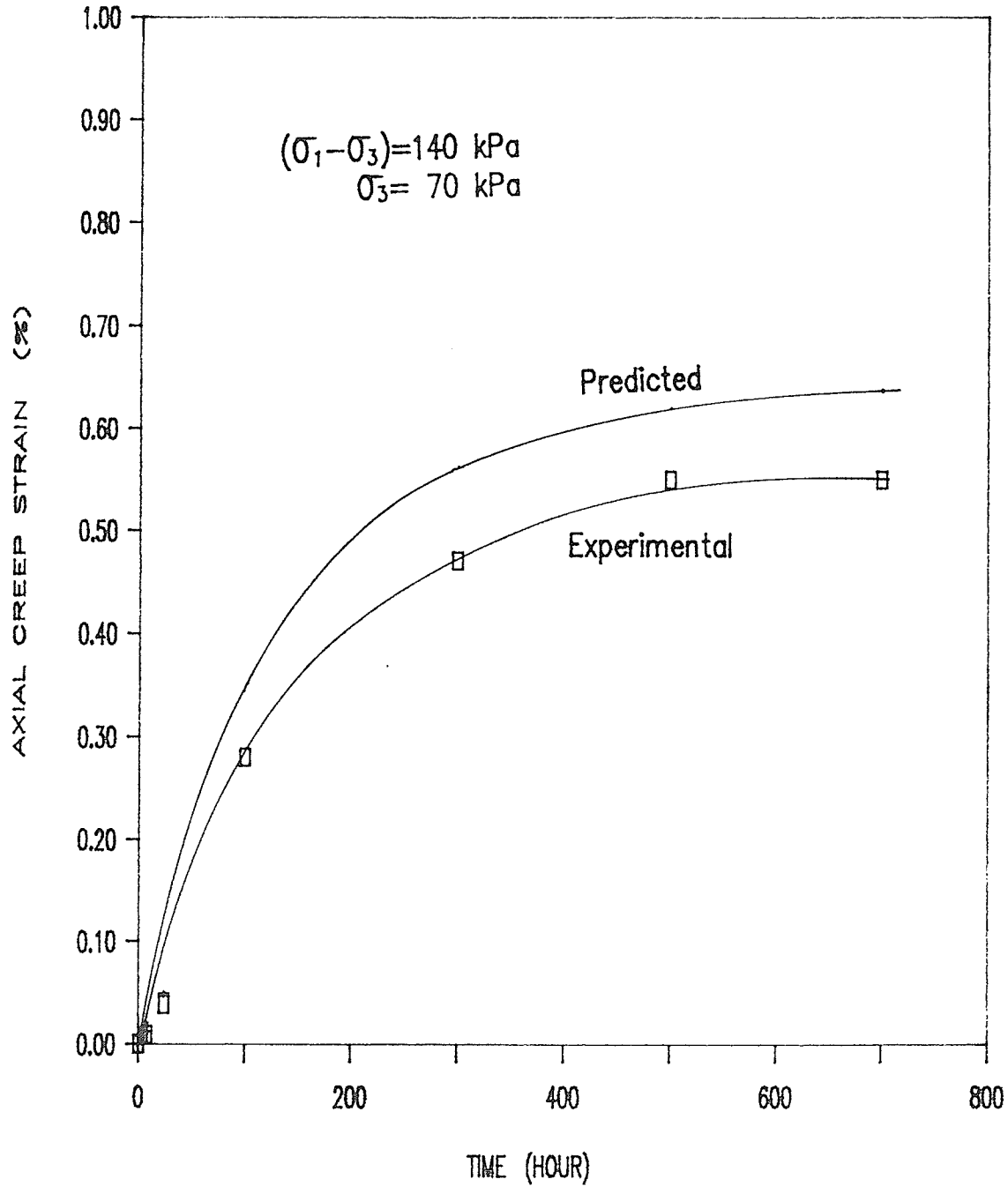

Figure 6.6 Axial creep strain versus time $(\sigma_1-\sigma_3)$=140 kPa

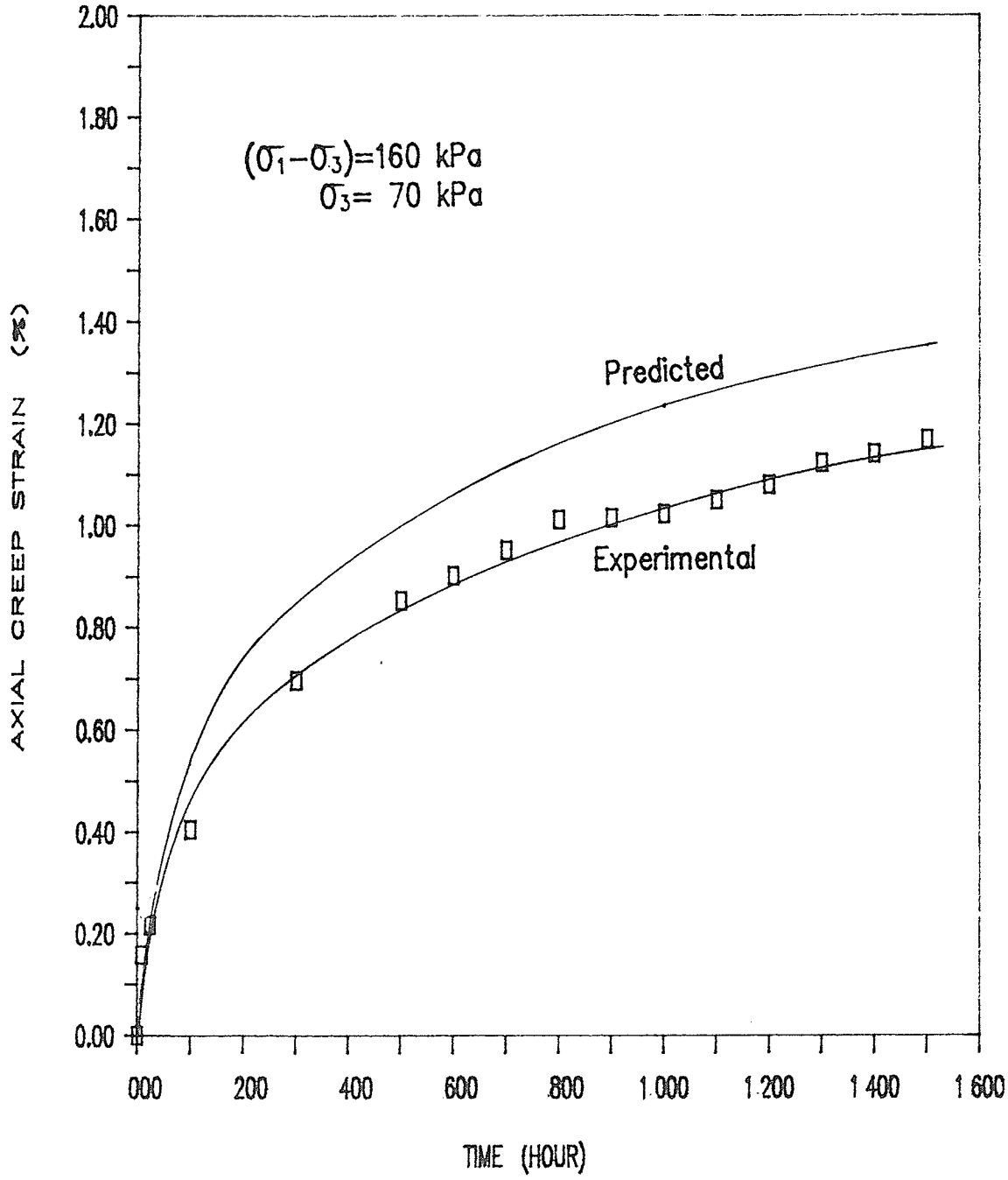

Figure 6.7 Axial creep strain versus time $(\sigma_1-\sigma_3)$=160 kPa

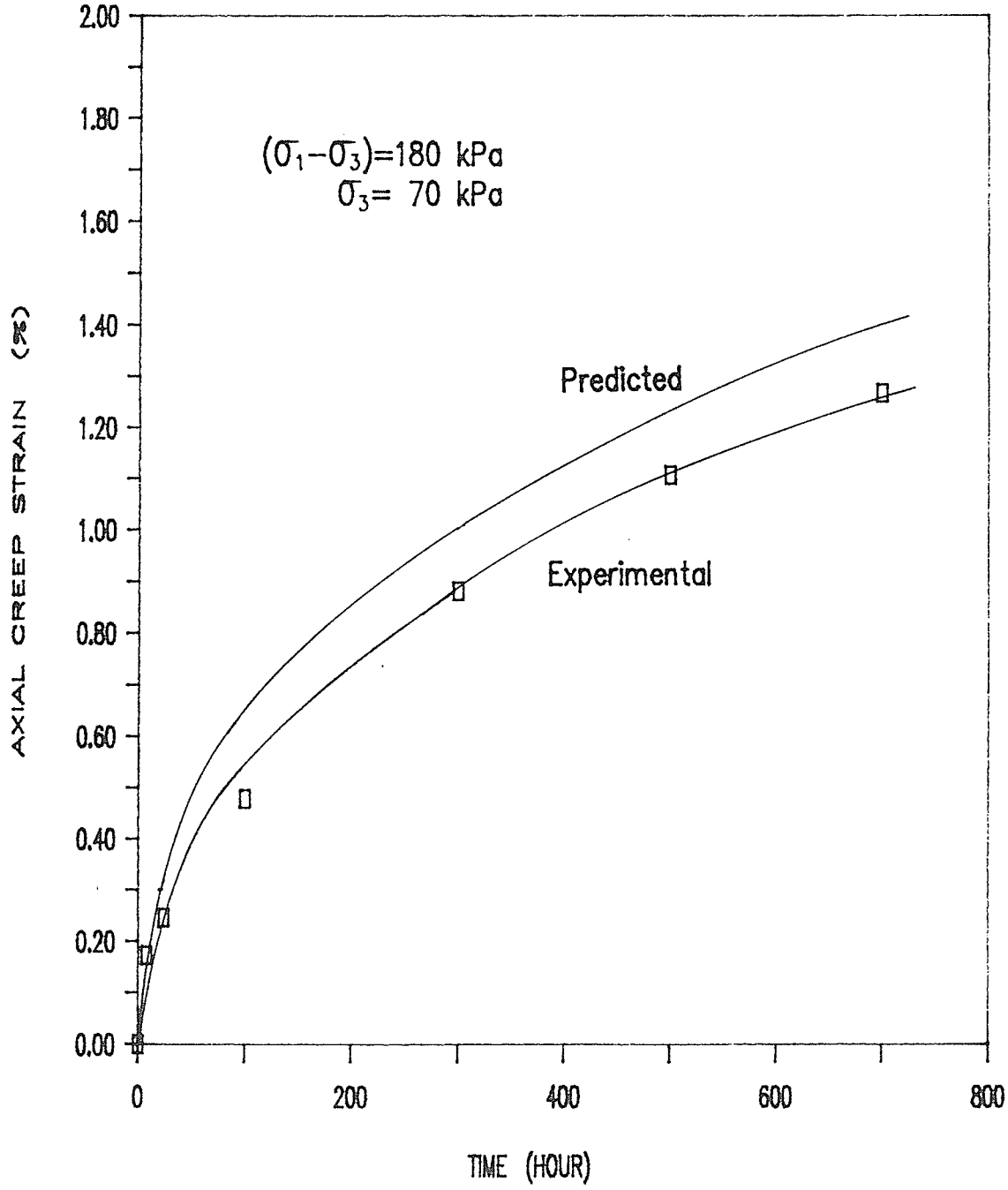

Figure 6.8 Axial creep strain versus time $(\sigma_1-\sigma_3)$=180 kPa

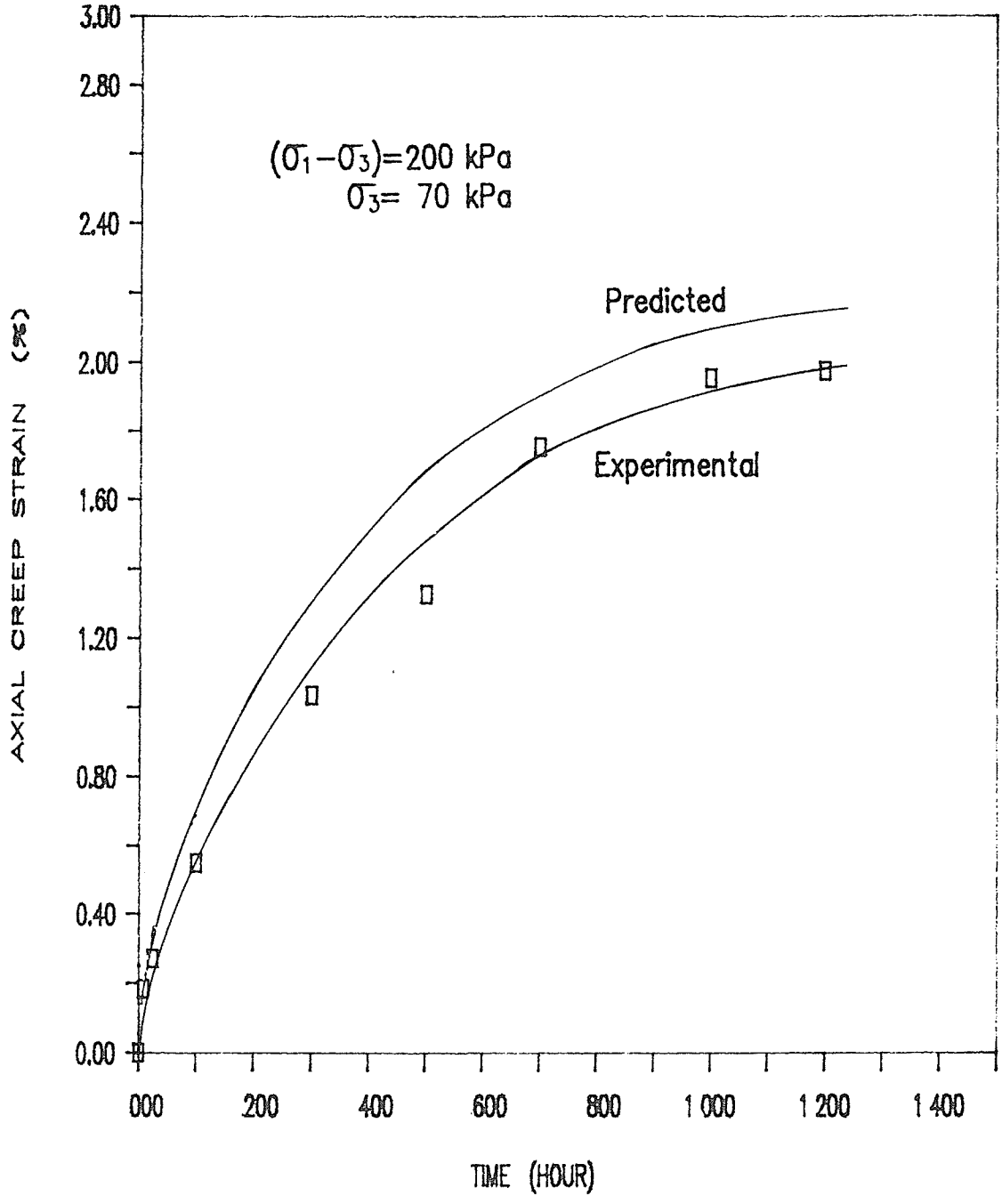

Figure 6.9 Axial creep strain versus time $(\sigma_1-\sigma_3)$=200 kPa

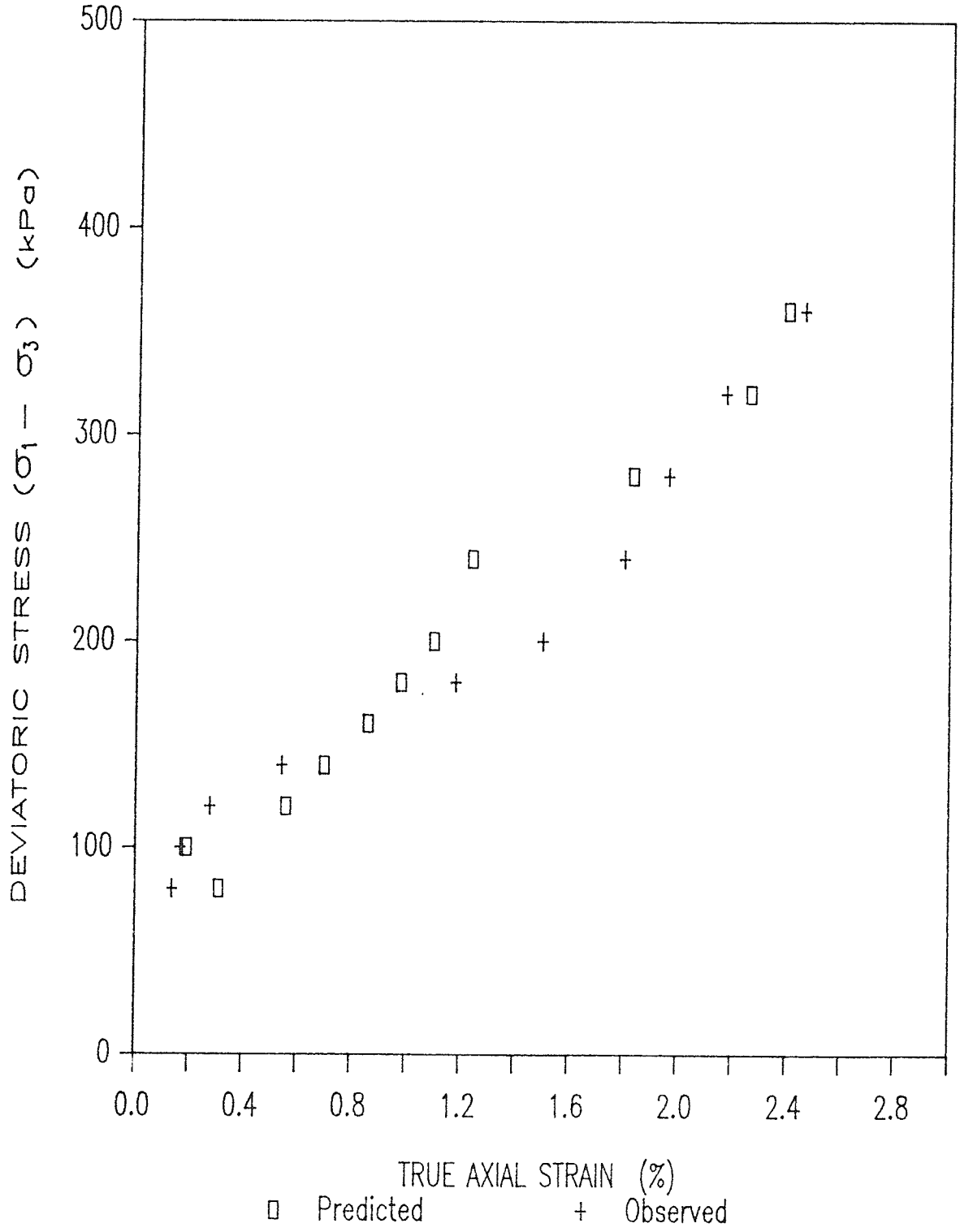

Figure 6.10 Deviatoric stress versus attenuated true axial stress (MST10)

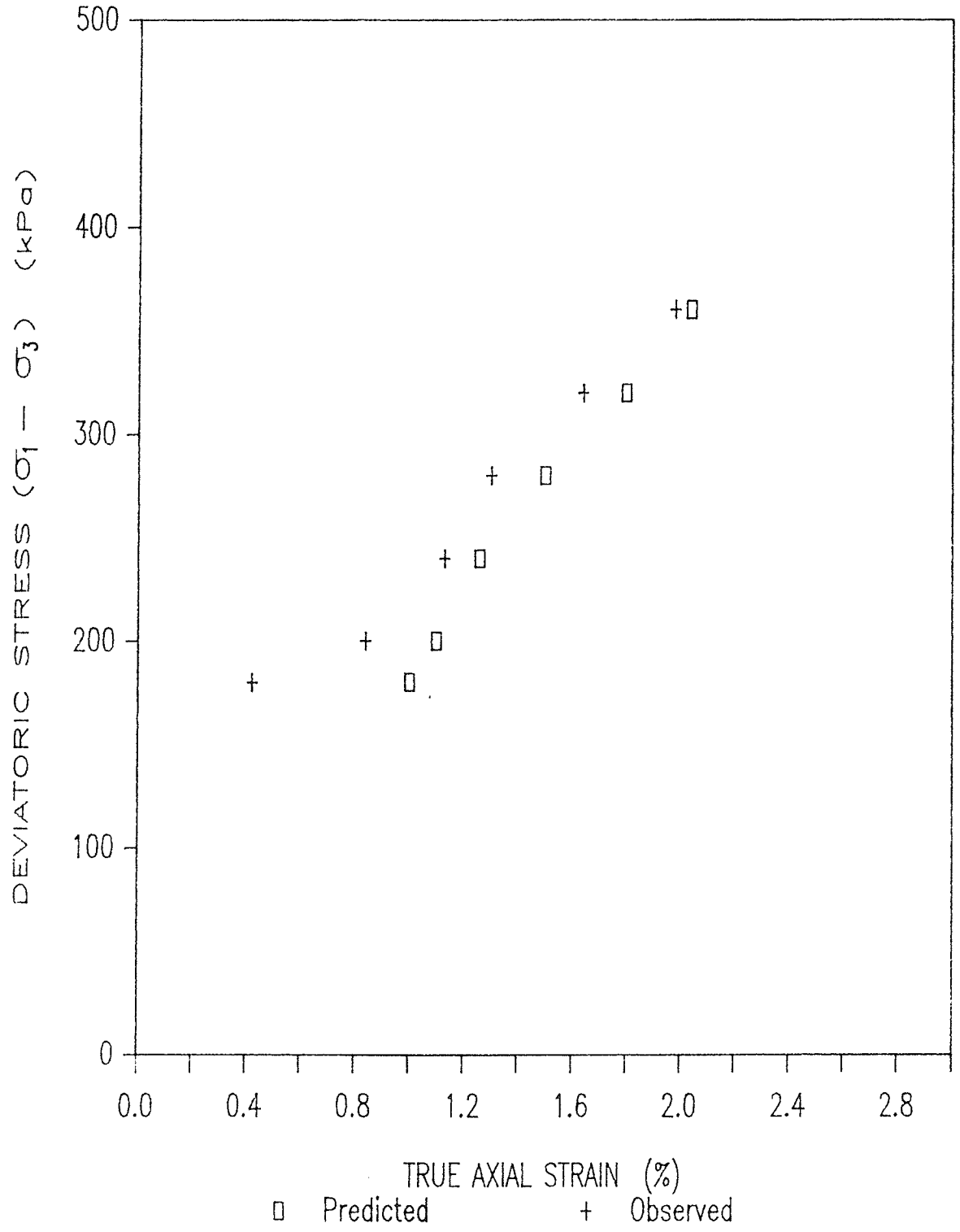

Figure 6.11 Deviatoric stress versus attenuated true axial stress (MST12)

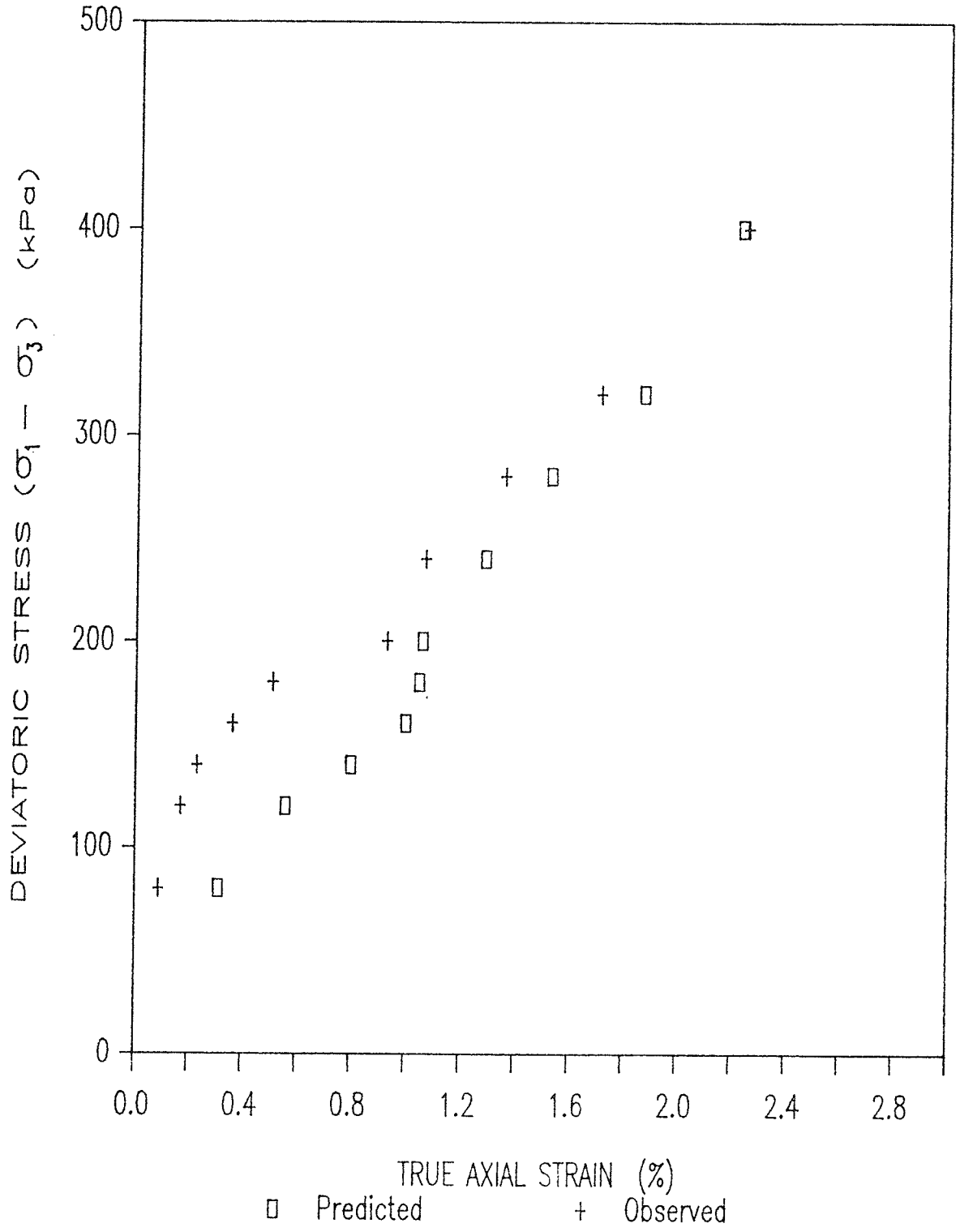

Figure 6.12 Deviatoric stress versus attenuated ture axial strain (MST13)

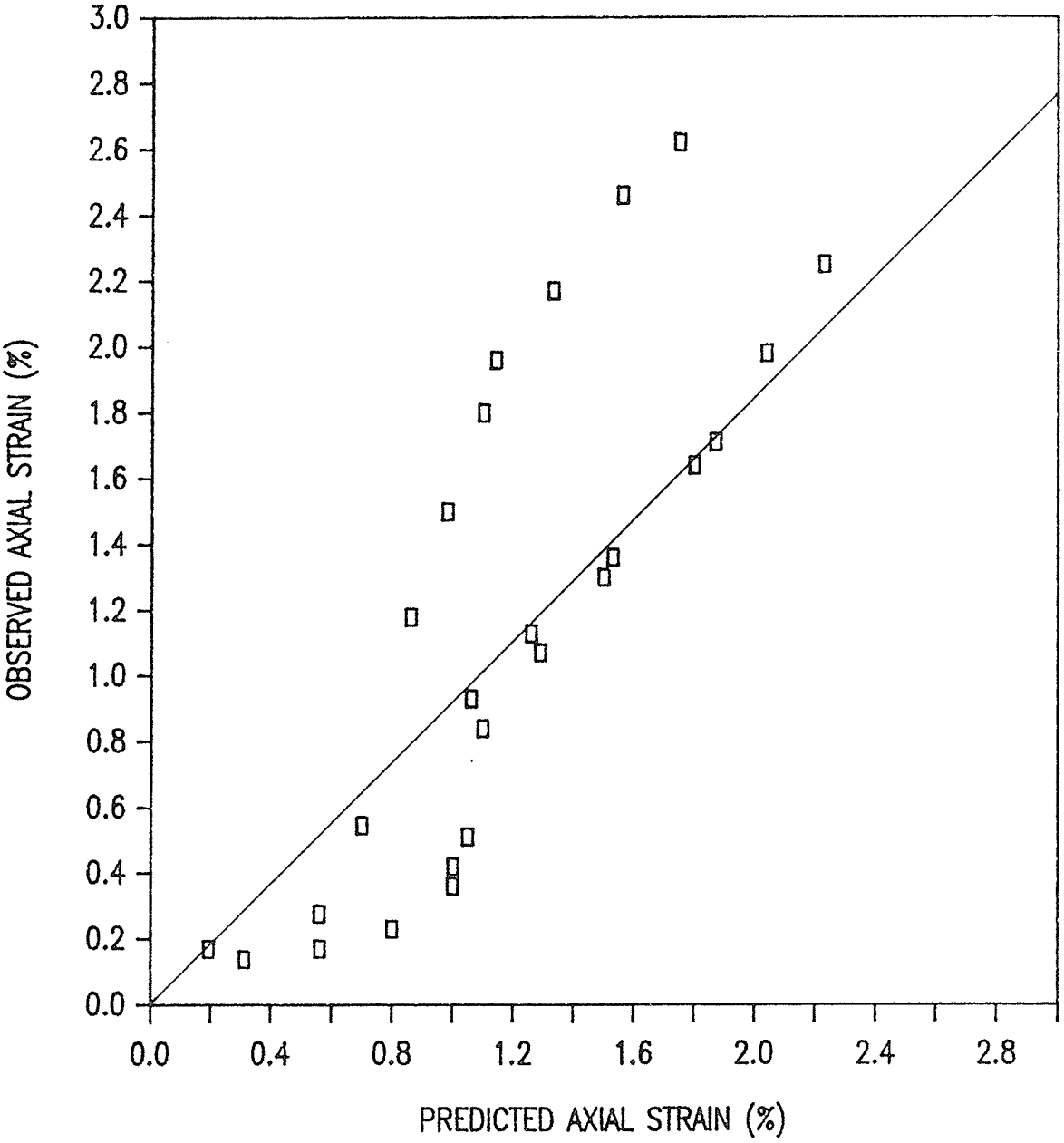

Figure 6.13 Observed axial strain versus predicted axial strain

CHAPTER SEVEN
DILATION AND FAILURE

CHAPTER 7

DILATION AND FAILURE

7.1 INTRODUCTION

A variety of deformation mechanisms, such as, micro-cracking, closure and/or opening of existing cracks, movement of grain boundaries, recrystallization of ice etc occur in frozen soils. Some of the mechanisms tend to strengthen the soil through densification known as strain-hardening, while others tend to weaken the soil through dilation which constitutes in part at least, strain-softening. As mentioned previously, in the long-term tests reported herein, it was found that generally the onset of dilation coincided with the start of accelerating creep. Mechanistically, this makes sense since dilation is associated with opening of cracks and an increase in voids. Thus one could conceivably use the onset of dilation as a failure criterion. However this would require long-term tests, particularly at low stress levels. For this reason an investigation was carried out to determine if dilation occurred at approximately the same stress conditions irrespective of the duration of the test. The investigation was to determine if the start of dilation was governed primarily by the stress state or by the magnitude of accumulated strains. This was done by running a series of short-term, constant mean normal stress tests and

comparing the stress states at which dilation started, in the case of the long and short-term tests.

7.2 TEST PROCEDURE

7.2.1 Constant Mean Normal Stress Multi-stage Short-term Triaxial Tests

Four short-term constant mean normal stress multistage triaxial tests were performed. The sample preparation techniques and test procedures were those described in Sections 3.2 and 5.2.1 respectively. The physical properties of the samples are given in Table 7.1. The tests were conducted under similar stress condition to those presented in Chapter 5, but were short-term. The deviatoric stresses were increased in steps approximately every 24 hours irrespective of the creep state.

7.3 TEST RESULTS

7.3.1 MST6

In this test the mean normal stress was 70 kPa and the increment of resultant deviatoric stress component, S_d, was 24.5 kPa. Six stepwise increments of deviatoric stress were applied. Details of the stress applications are given in Table 7.2 and the axial and volumetric deformations are given in the Appendix.

The cumulative true axial and true volumetric strains versus time for the entire test are shown in Figure 7.1. The strain-time data indicated that dilation occurred at the stress step, S_d=147 kPa. The volume change reversal was abrupt coinciding with the change in step. An abrupt increase in axial creep was also observed at the same stress step.

7.3.2 MST7

In this test the mean normal stress was 140 kPa and the increment of resultant deviatoric stress, S_d, was 49 kPa. Seven stepwise increments of deviatoric stress were applied. Details of the stress applications are given in Table 7.3 and the axial and volumetric deformations are given in the Appendix.

The cumulative true axial and true volumetric strains are shown plotted against time for the entire test in Figure 7.2. The dilation occurred at the stress step, S_d=294 kPa, with an abrupt increase in volumetric strain. The axial creep accelerated at the same stress step.

5.3.8 MST8

In this test the mean normal stress was 280 kPa and the

incremental resultant deviatoric stress was 73.5 kPa. Eleven stepwise increments of deviatoric stress were applied. Details of the stress applications are given in Table 7.4 and the axial and volumetric deformations are given in the Appendix.

The cumulative true axial and true volumetric strains versus time for the entire test are shown in Figure 7.3. The strain-time data indicated that dilation occurred at the stress level, S_d=661 kPa with an abrupt increase in volumetric strain. The axial creep accelerated at the same stress level.

7.3.4 MST9

The mean normal stress, in this test, was 420 kPa and the incremental resultant deviatoric stress was 98 kPa. Eleven stepwise increments of deviatoric stress were applied. Details of the stress applications are given in Table 7.5 and the axial and volumetric deformations are given in the Appendix.

The cumulative true axial and true volumetric strains versus time for the entire test are shown in Figure 7.4. The strain-time data indicated that dilation occurred at the stress step, S_d=980 kPa with an abrupt increase in volumetric strain. The axial creep accelerated at the same stress level.

7.4 DISCUSSION OF TEST RESULTS

7.4.1 Failure Mechanisms

It was observed from the true axial and true volumetric strains versus cumulative time curves (Figures 7.1 through 7.4) that in the short-term tests the sample decreased in volume initially upon application of the deviatoric stresses. At successive increments of the deviatoric stresses, the samples continued to decrease in volume until a threshold stress was reached, at which time the samples started to dilate. The same phenomenon was observed in the long-term tests, as described in Section 5.3. In all of the long-term tests it was observed that the dilation was gradual while in all of the short-term tests an abrupt reversal in volume was observed. This may be attributed to the phenomenon that in the long-term tests the stresses were more evenly distributed between the ice matrix and the sand particles whereas in the short-term tests the time elapsed between increments was too short for even distribution, and most of the stresses were carried by the sand particles bearing on the ice matrix. Consequently, a greater portion of the stress was carried by the ice matrix and failed suddenly transferring the stress to grain to grain.

The resultant deviatoric stress at the beginning of dilation for both types of tests were plotted against mean normal stress in Figure 7.5. The resultant deviatoric stresses for the short-term tests were greater than those for the long-term tests beyond a stress of about 100 kPa. This plot can be used as failure criteria and has been discussed in sections 5.4.1 and 5.4.3. This plot also signifies that

the onset of dilation or failure is not strictly a stress phenomena.

The axial cumulative strains at the beginning of dilation were plotted against the mean normal stress in Figure 7.6. The axial strain at dilation increased approximately linearly with the mean normal stress in both test series. The increase in failure strain with increased mean normal stress can be explained by the concept of ductile fracture which generally occurs by the formation and subsequent growth of and coalescence of voids and cavities. If the cavity nucleation can be delayed or suppressed altogether, large increase in ductility can be achieved. By increasing the mean normal stress the dilation or the opening up of the cracks are suppressed and delayed, and thereby the axial strain at dilation increases. The cumulative strains at the start of dilation were greater for the long-term tests than for the short-term tests for a given mean normal stress which means that failure is not solely governed by the magnitude of the accumulated strain.

The cumulative axial strains at the beginning of dilation were plotted against the ratio of mean normal stress and resultant deviatoric stress in Figure 7.7. The ratios were found to lie within a narrow range of 0.41 to o.71. This plot indicates that the ratio of mean normal stress to resultant deviatoric stress must be higher than o.41 to occur any failure and below this attenuating creep will occur.

TABLE 7.1

Physical Properties of Frozen Sand Sample

Sample	Dry Unit Weight (KN/m^3)	Water Content (%)	Porosity (%)	Water Saturation (%)	Sample Test Temp. (^oC)
MST6	16.0	22.8	40.6	87.0	-3
MST7	15.9	22.5	40.9	88.0	-3
MST8	16.0	23.2	40.7	91.0	-3
MST9	16.3	22.2	39.5	91.6	-3

TABLE 7.2

Details of Stress Application

Test MST6 σ_m=70 kPa

σ_1 (kPa)	σ_3 (kPa)	S_d (kPa)	Duration of Stress Application (Hour)
70	70	0	789
110	50	49.0	22
130	40	73.5	23
150	30	98.0	23
170	20	122.5	24
190	10	147.5	23
210	0	171.5	746

TABLE 7.3

Details of Stress Application

Test MST7 σ_m=140 kPa

σ_1 (kPa)	σ_3 (kPa)	S_d (kPa)	Duration of Stress Application (Hour)
140	140	0	791
180	120	49.0	22
220	100	98.0	23
260	80	147.0	23
300	60	196.0	24
340	40	245.0	23
380	20	294.0	23
420	0	343.0	719

TABLE 7.4

Details of Stress Application

Test MST8 σ_m=280 kPa

σ_1 (kPa)	σ_3 (kPa)	S_d (kPa)	Duration of Stress Application (Hour)
280	280	0	431
340	250	73.5	24
400	220	147.0	23
460	190	220.5	23
520	160	294.0	24
580	130	367.4	23
640	100	440.9	23
700	70	514.4	23
760	40	587.9	24
820	10	661.4	23
840	0	685.9	651

TABLE 7.5

Details of Stress Application

Test MST9 σ_m=420 kPa

σ_1 (kPa)	σ_3 (kPa)	S_a (kPa)	Duration of Stress Application (Hour)
420	420	0	454
500	380	98.0	24
580	340	196.0	23
660	300	294.0	23
740	260	392.0	24
820	220	490.0	23
900	180	588.0	25
980	140	686.9	24
1060	100	783.8	25
1140	60	881.8	23
1220	20	979.8	24
1260	0	1028.8	632

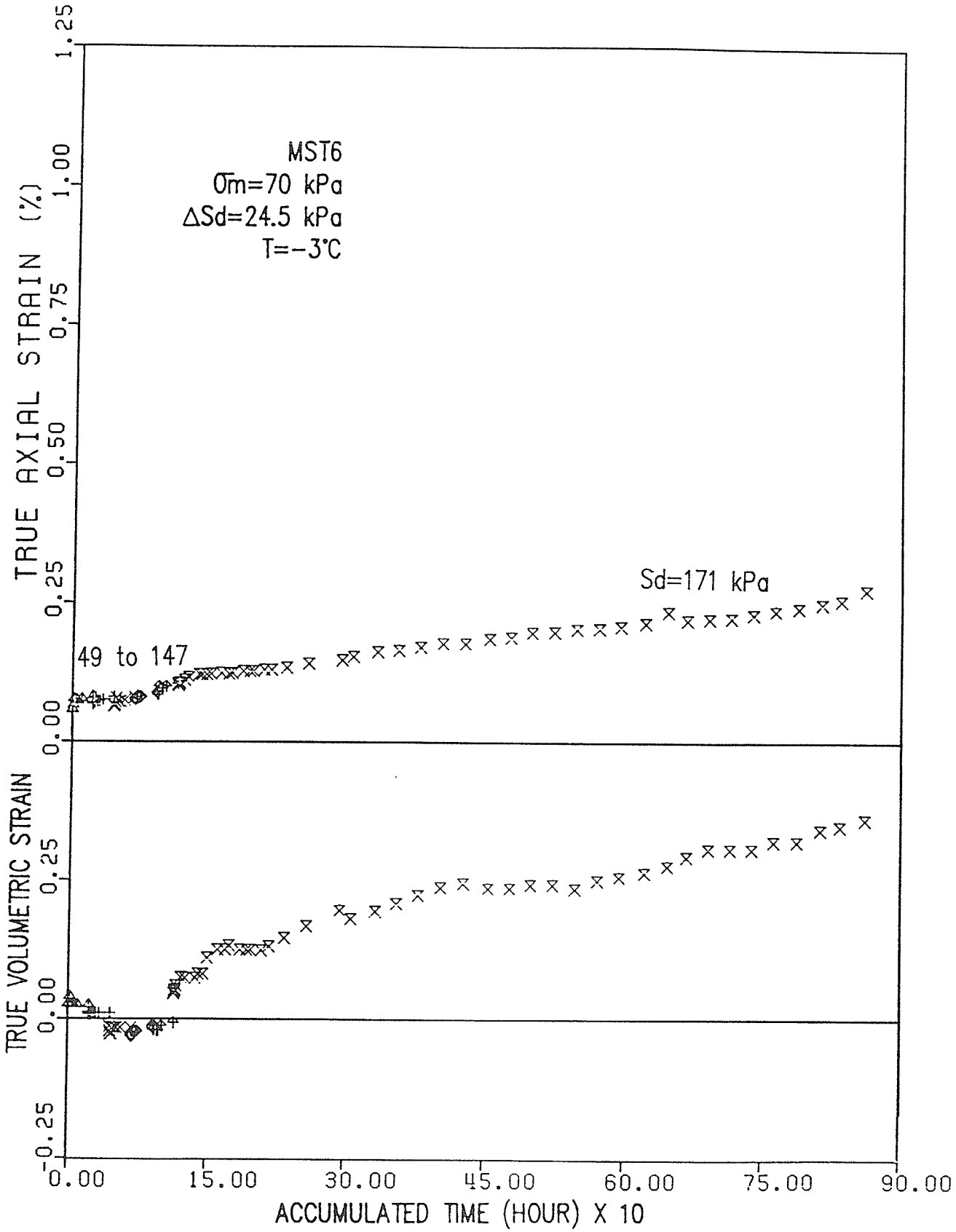

Figure 7.1 True volumetric and true axial strain versus accumulated time (MST6)

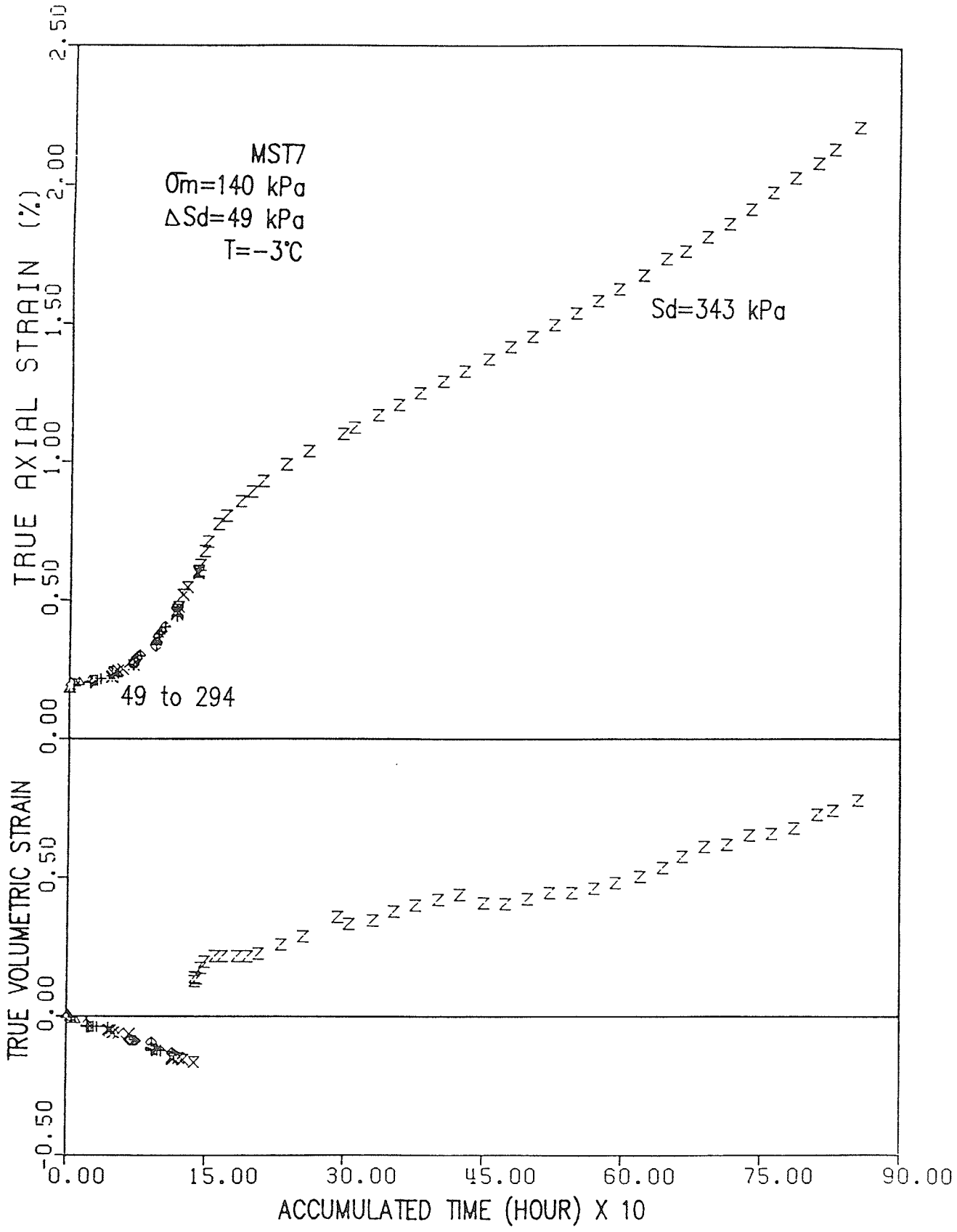

Figure 7.2 True volumetric and true axial strain versus accumulated time (MST7)

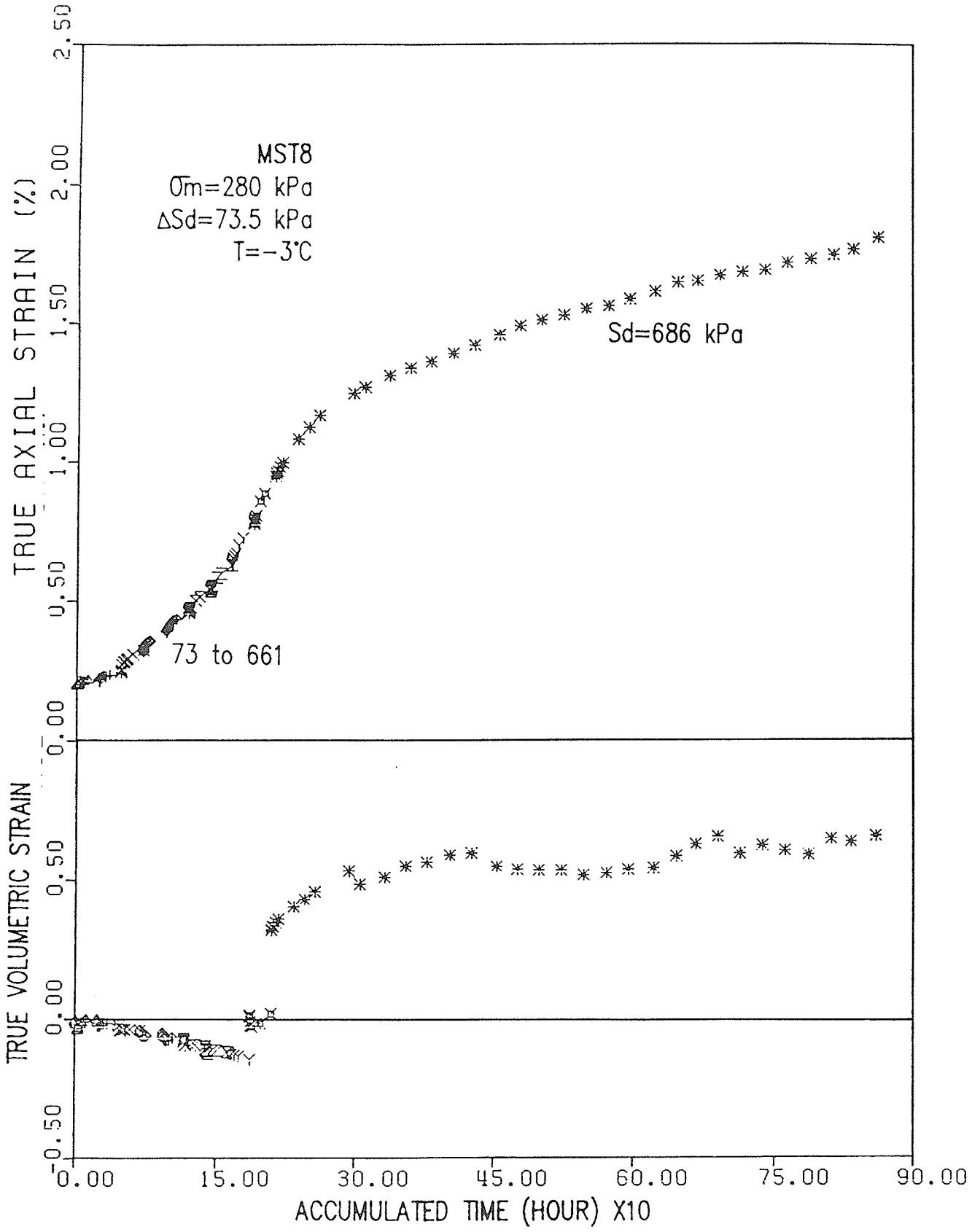

Figure 7.3 True volumetric and true axial strain versus accumulated time (MST8)

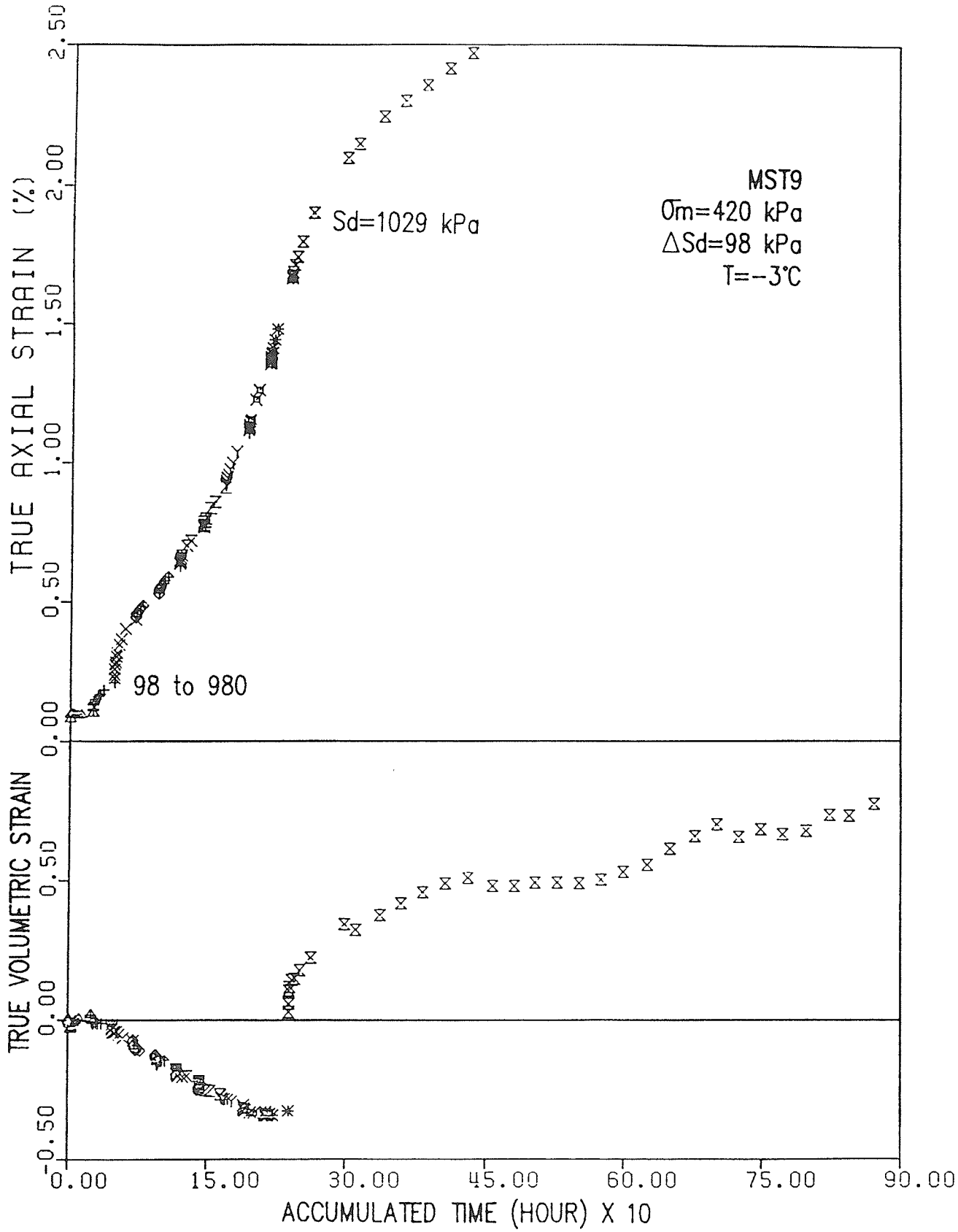

Figure 7.4 True volumetric and true axial strain versus accumulated time (MST9)

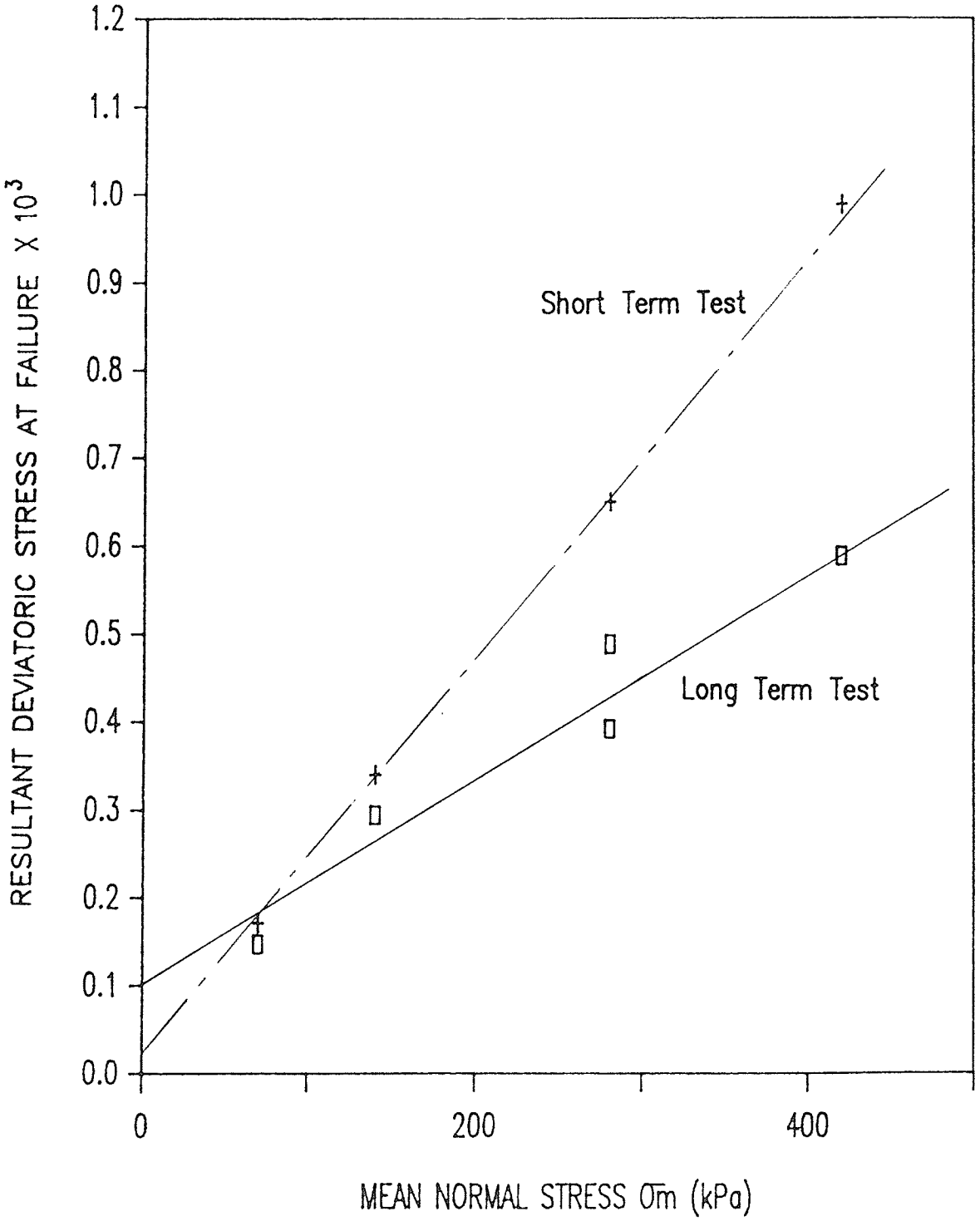

Figure 7.5 Resultant deviatoric stress at failure versus mean normal stress

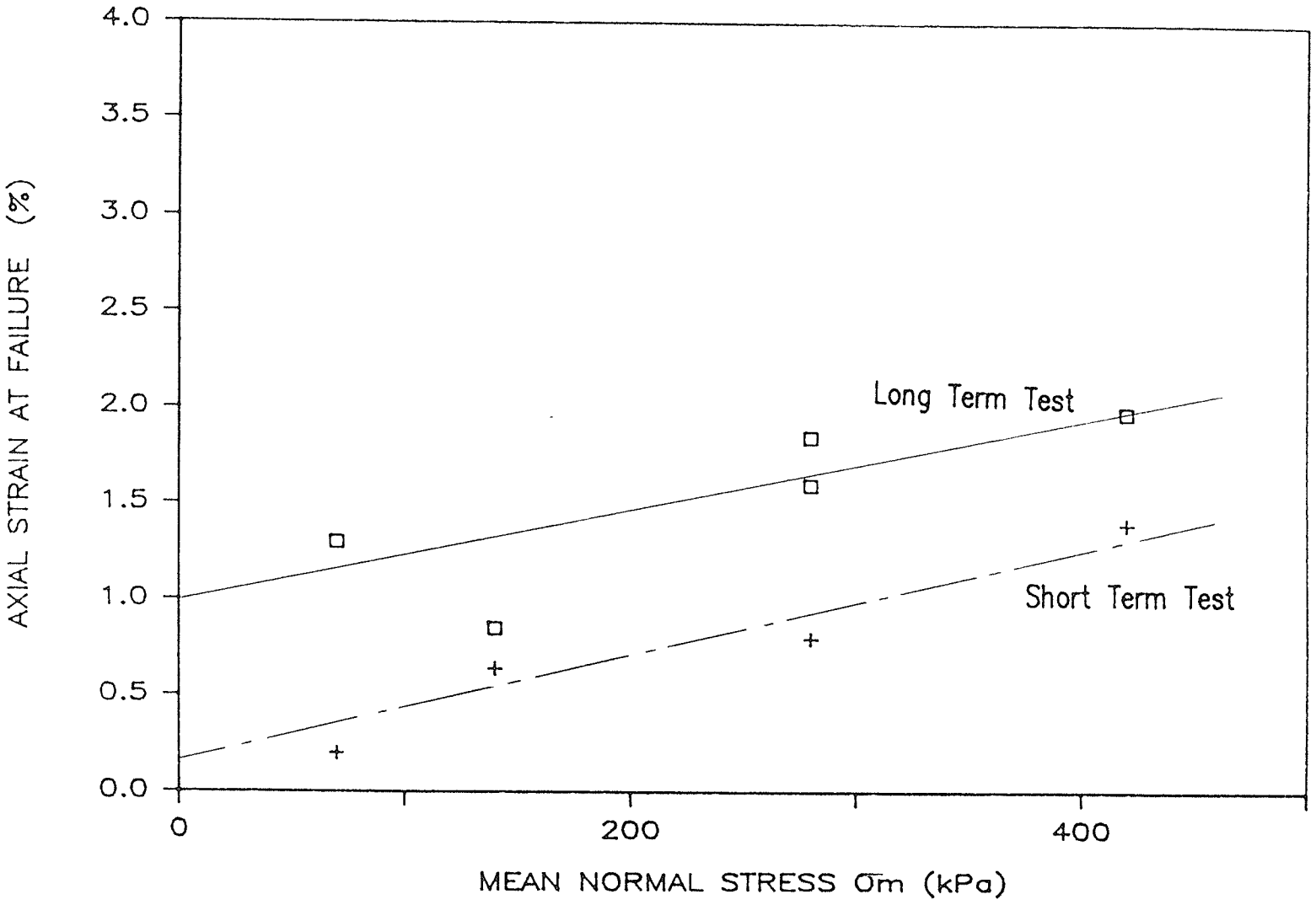

Figure 7.6 Axial strain at failure versus mean normal stress

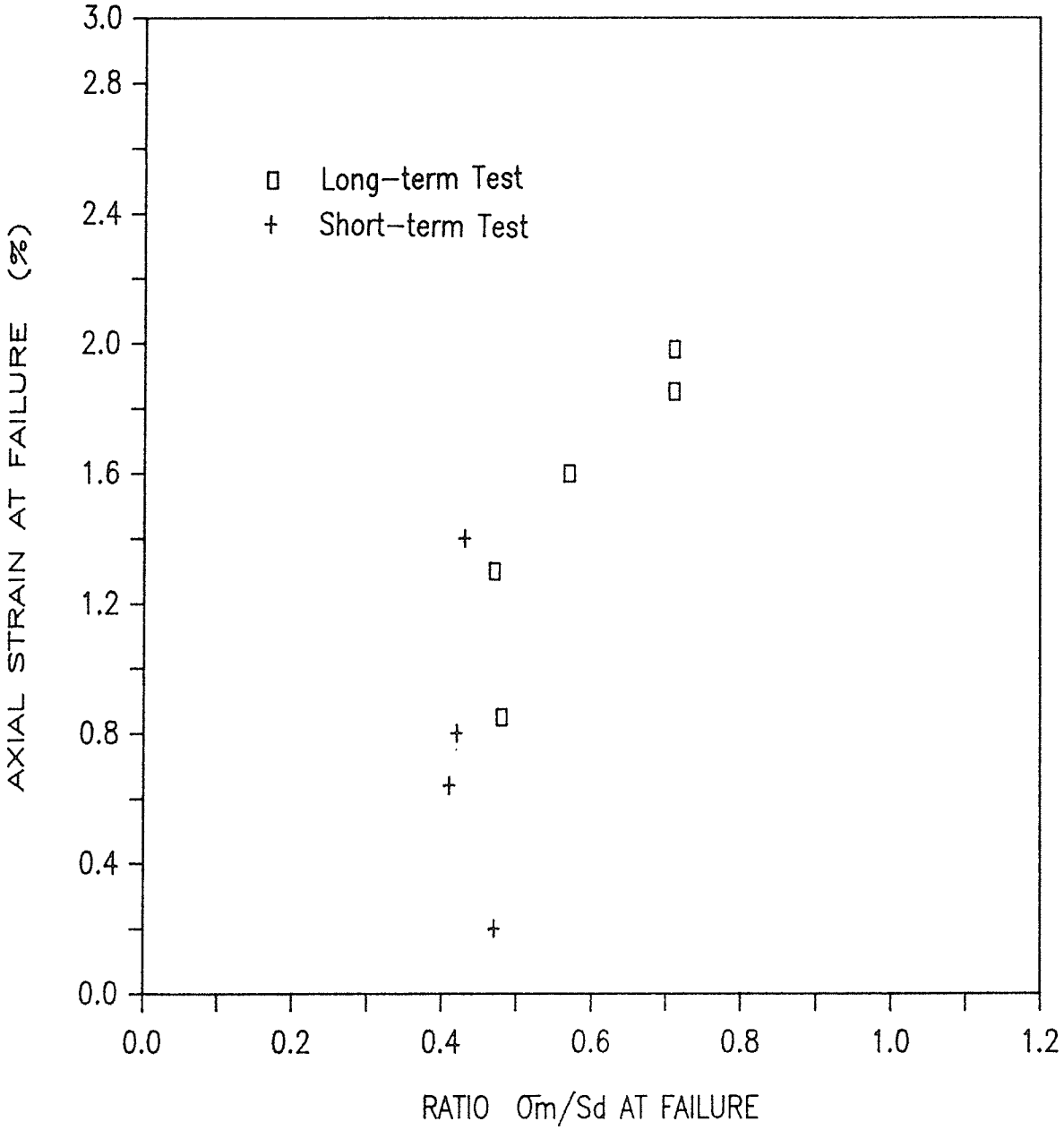

Figure 7.7 Axial strain at failure versus ratio σm/Sd at failure

CHAPTER EIGHT
INTERACTION OF RIGID PARTICLES AND ICE

CHAPTER 8

INTERACTION OF RIGID PARTICLES AND ICE

8.1 INTRODUCTION

Although the creep behaviour of ice and frozen soil has been studied extensively during the last decade, very little systematic information is available on the interaction of soil particles and their matrix material, namely ice. As described in chapter 2, the frozen soil is a composite mixture of soil particles, ice, unfrozen water and gases. The soil particles have the highest relative stiffness among its constituents. In an ice rich or fully ice saturated soil, the soil particles are surrounded by ice. When stressed, the soil particles, because of their high relative stiffness, penetrate or flow into the ice mass.

An attempt was made to simulate the interaction between soil particles and ice by loading rigid spheres which had been half-embedded into polycrystalline ice and monitoring the movement of the spheres with time.

8.2 TEST PROGRAM

8.2.1 Ice Sample Preparation

Samples of polycrystalline ice were prepared in 108 mm diameter by 120 mm long plexiglass molds. The molds were half-filled with tap water and placed in a cold room at -3°C. When the water was super-cooled to a temperature of 0 to -1°C, ice chips were added to fill the mold to the top. The molds were then insulated with molded foam insulation leaving the bottom 25 mm and the base uninsulated. The molds were then placed on metal stands in a freezer at -20°C. The samples were frozen unidirectionally upward. This procedure of unidirectional freezing resulted in upward expansion thus avoiding the build up of a large lateral stresses.

A steel spherical ball was placed at the centre of each sample during the latter stage of freezing when the top 6 mm was still unfrozen. The balls were held in place by a styrofoam cover with a hemispherical hole in its centre.

A schematic of the spherical ball and the ice sample is shown in Figure 8.1 to scale.

8.2.2 Loading Procedure

The samples were taken out of the freezer and placed in a cold room for about 24 hours to attain equilibrium at the room temperature

which was -3°C. A dead weight hanger system was used to apply the load to the steel balls. The whole assembly was placed inside an insulated cabinet to minimize temperature variations during the defrosting cycle of the cold room.

The first test series consisted of loading spheres having a diameter of 11.57 mm to loads of 62.8 N, 85.1 N, 107.4 N and 129.6 N respectively. Dial gauges with an accuracy of 0.01 mm were used to monitor the penetration of the spheres with time. After 1100 hours of load application, the loads were removed, and rebound was allowed to reach equilibrium. The monitoring of the sphere movement was continued during unloading and rebound.

The spheres were then reloaded with higher loads of 151.8 N, 174.1 N, 196.0 N and 218.6 N. The monitoring of the movement of the spheres was continued.

In the second test series, spheres having diameters of 9.5 mm, 15.9 mm, 18.2 mm, and 23.7 mm respectively, were loaded with a constant hemispherical stress of 298.6 kPa. The monitoring of the movement of the spheres was carried out as before.

8.3 TEST RESULTS

8.3.1 Constant Sphere Diameter Tests

The results of the tests in which spheres with a constant diameter were subjected to a variety of loads are shown in Figure 8.2. It can be seen that with the exception of the test in which the load was 129.6 N, there was no significant instantaneous penetration of the steel balls into the ice at the start of the load applications. Thus it would appear that the instantaneous penetration under the 129.6 N load was an abberation caused perhaps by imperfect contact between the sphere and the ice. As well there was no measurable rebound upon unloading, indicating that all of the penetration was due to plastic deformation of the ice.

The relationship between penetration and time was essentially linear for the range of load used. The rate of penetration increased with an increase in load. The relationship between the penetration rate and the average hemispherical stress acting on each sphere is shown in Figure 8.3. The rates increased with the applied stress at an increasing rate. This was to be expected, since at a very high stress, the resistance of ice to penetration approaches zero and the rate of penetration approaches infinity.

The plot of penetration rate versus hemispherical stress linearized on log-log plot as shown in Figure 8.4. The relationship may therefore be expressed as :

$$\dot{S} = \dot{S}_o \, (\sigma/\sigma_o)^n \qquad (8.1)$$

in which $\dot{S}$ = penetration rate (mm/hour)

σ = hemispherical stress (kPa)

n = slope of the straight line defined as material parameter

=2.4

$\dot{S}_o$ and σ_o = coordinates of any point on the straight line

For frozen sand under a deep circular load, Ladanyi and Paquin (1984) stated that a steady state penetration rate can be attained after a limited period of time varying from a minimum of about 1 day upto 5 days. They also stated that the penetration rate became essentially a function of applied stress. For the ice under investigation, steady rates were achieved after about 1 day in all load cases and the penetration rates increased exponentially with applied stress.

8.3.2 Constant Hemispherical Stress Tests

The results of the four tests in which sphere diameters of 9.5 mm, 15.9 mm, 18.2 mm and 23.7 mm were subjected to a constant hemispherical stress of 298.6 kPa are shown in Figure 8.5. It can be seen that there was very little instantaneous penetration of the steel balls into the ice at the start of the load applications. As well there was no measurable rebound upon unloading indicating that essentially all the penetration was due to plastic deformation of the ice.

The relationship between penetration and time was essentially

linear for the stress and the spheres used and therefore the rate of penetration was approximately constant for the applied hemispherical stress. This penetration rate is included in Figure 8.6 along with the results of the first test series. The rates fits in well with the results the from first test series.

8.3.3 Viscosity

From the tests results as presented in Figure 8.2 it was revealed that the deformation, under sustained loading, in the polycrystalline ice was almost entirely plastic, as no noticeable recovery was observed after removal of the load at the end of the tests. The polycrystalline ice may be considered to have behaved as a non-Newtonian fluid in the range of the stresses and the temperature used in the tests. The rate of penetration in a non-Newtonian fluid can be represented by :

$$\frac{du}{dt} = \frac{\sigma}{\eta} \qquad (8.2)$$

in which du/dt = penetration rate

σ = applied stress

η = viscosity

For non-Newtonian fluid, the viscosity coefficient as defined in equation 8.2 is not a constant but varies with the applied stress. The viscosity coefficient computed for all the tests is shown plotted

against the applied stress in Figure 8.7. The viscosity coefficient varied nonlinearly with the applied stress and the relationship linearized on a semi-logarithmic plot with viscosity on the log scale as shown in Figure 8.8. Accordingly, the viscosity of the polycrystalline ice can be represented by the following equation :

$$\eta = ce^{-m\sigma} \tag{8.3}$$

in which η = viscosity (Pa Sec/m)

c = constant dependent on temperature and ice type

= $1.3\ 10^{13}$ Pa sec/m at $\sigma=0$

m = slope of the straight dependent on temperature and ice type

η = $1.0258\ 10^{-3}$ for T=-3°C.

σ = applied hemispherical stress

The equation indicates that the viscosity coefficient of polycrystalline ice decreases exponentially with the applied hemispherical stress. Jellinek et al (1956) also observed that for polycrystalline ice, the viscosity coefficient decreased with applied stress.

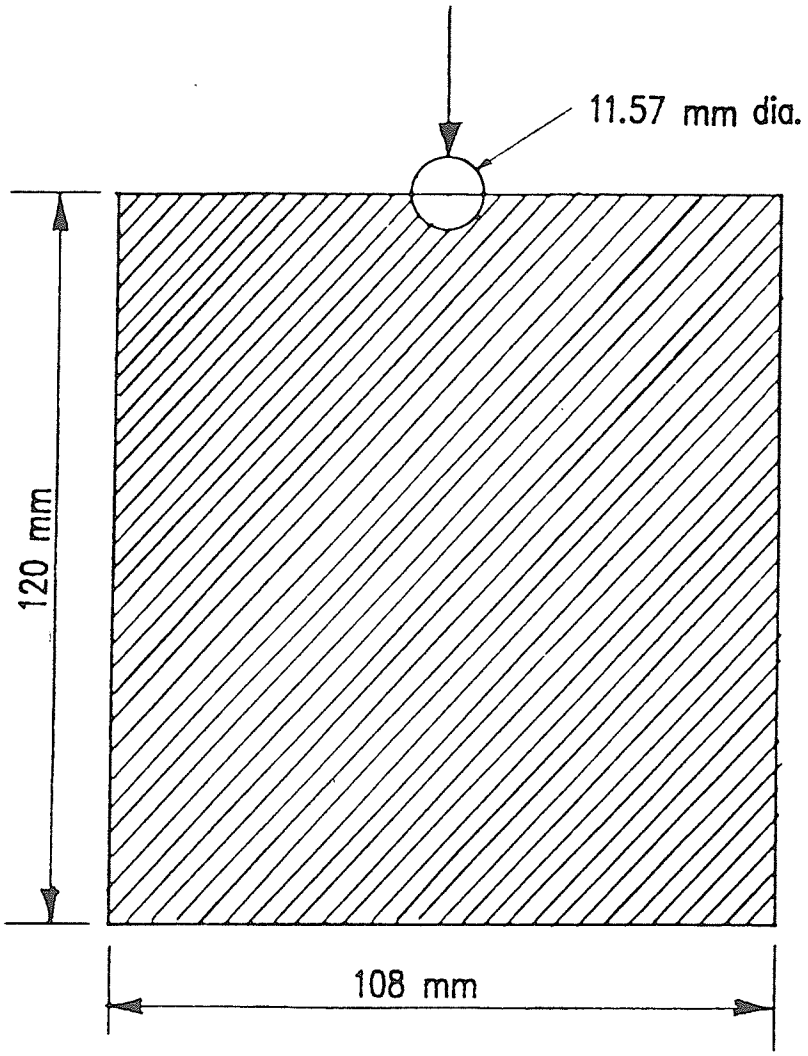

Figure 8.1 Ice sample with steel sphere at the centre

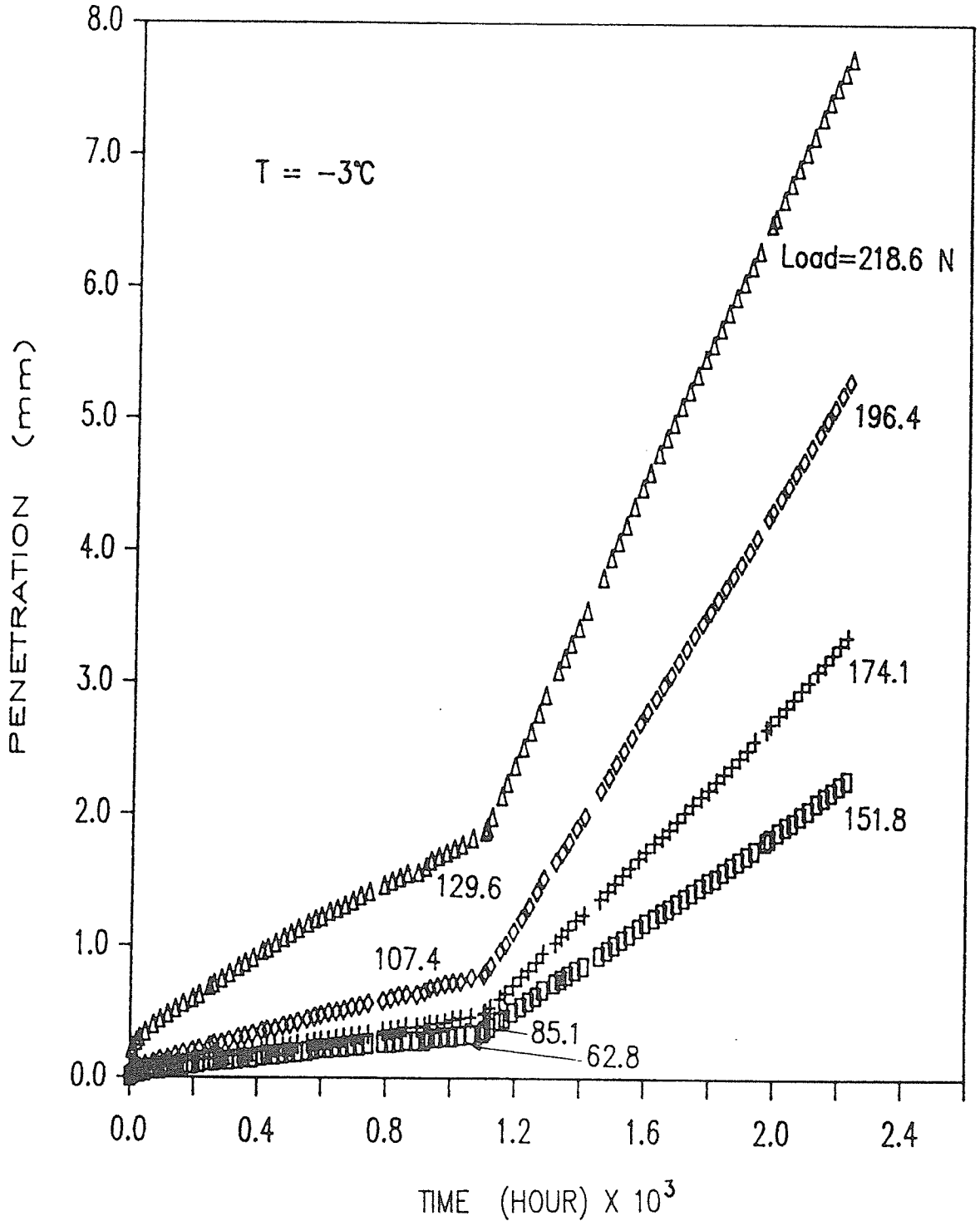

Figure 8.2 Penetration of steel spheres versus accumulated time (Tests--Phase 1 and Phase 2)

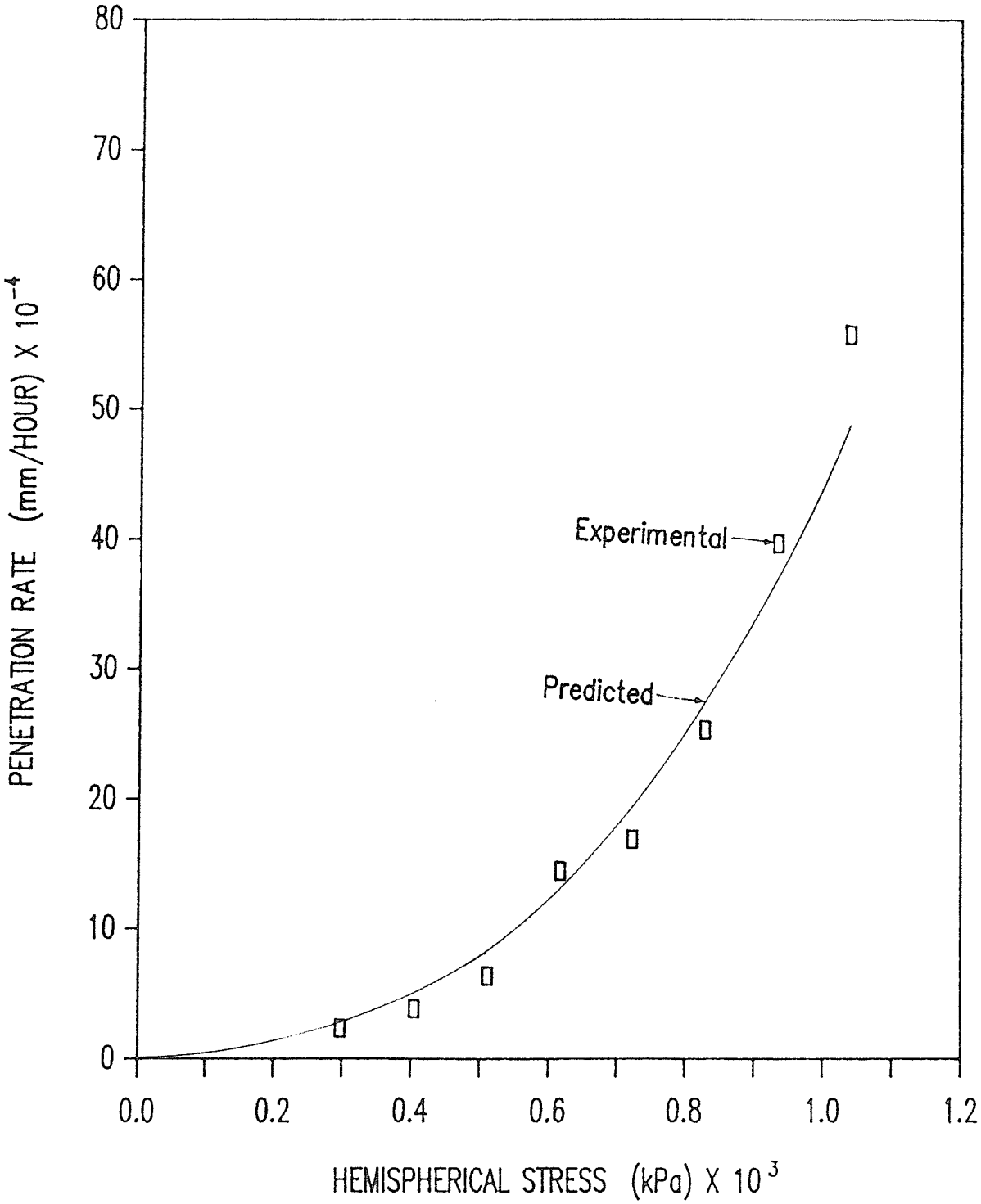

Figure 8.3 Penetration rate versus hemispherical stress

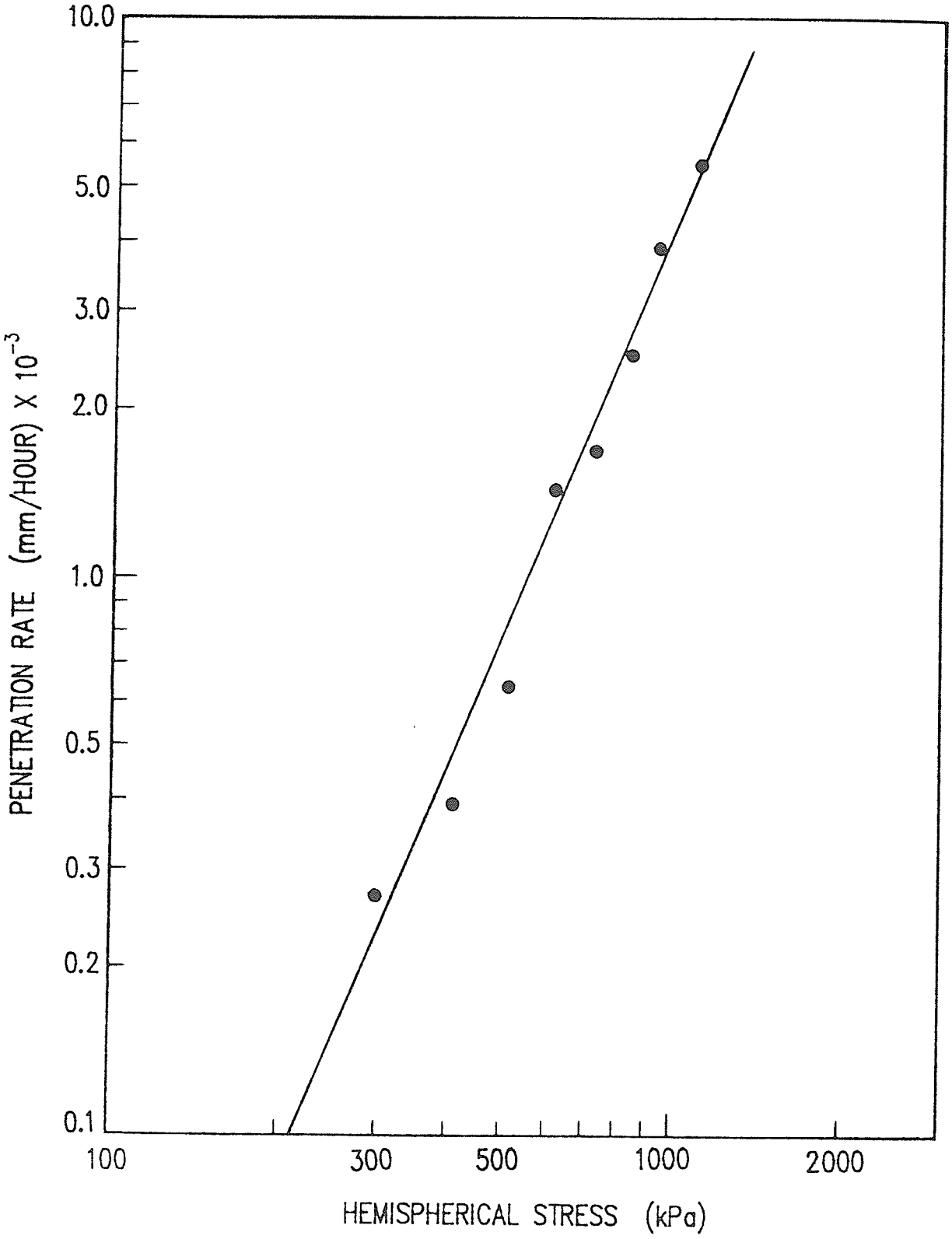

Figure 8.4 Penetration rate versus hemispherical stress

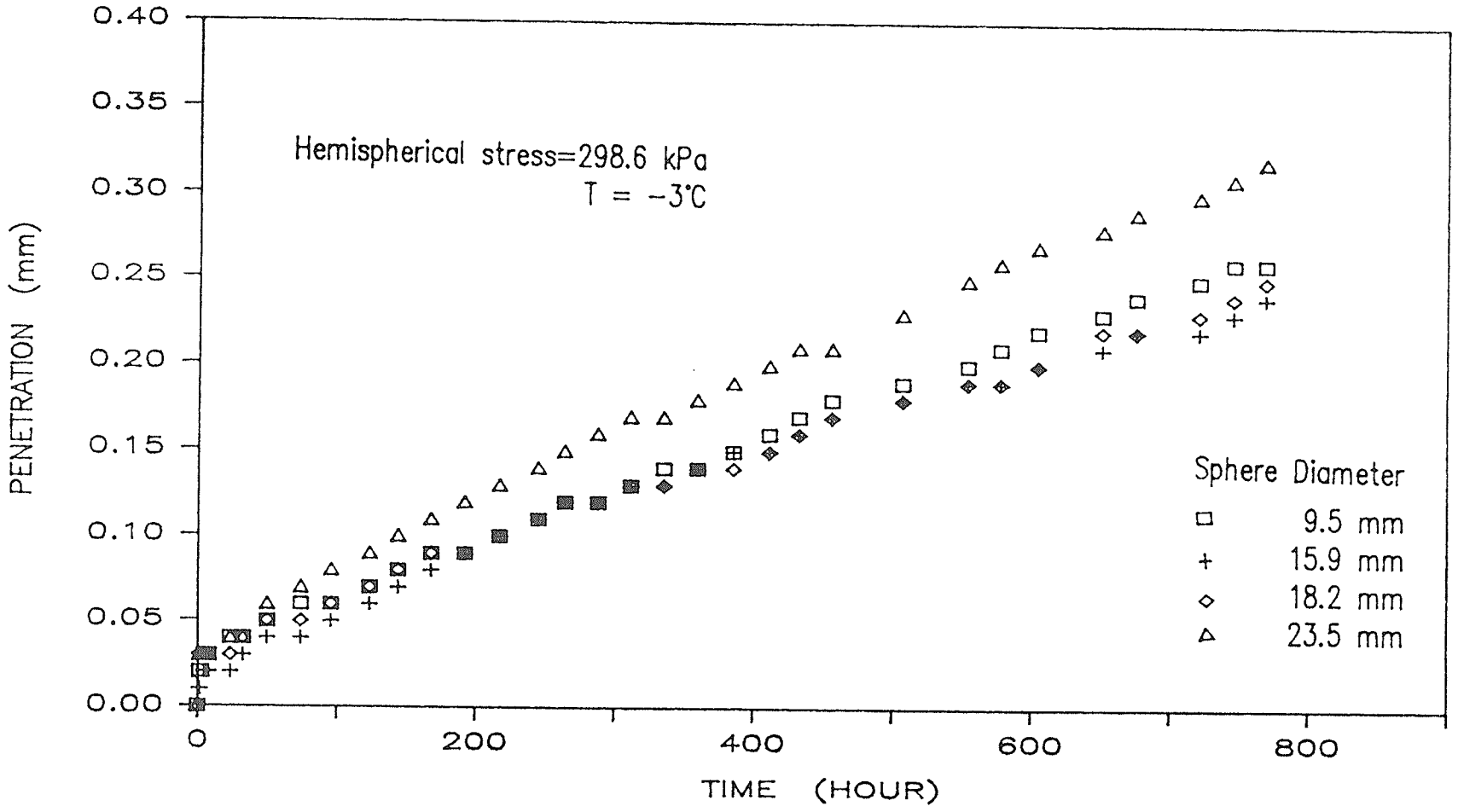

Figure 8.5 Penetration of steel spheres versus time (Tests – Series 2)

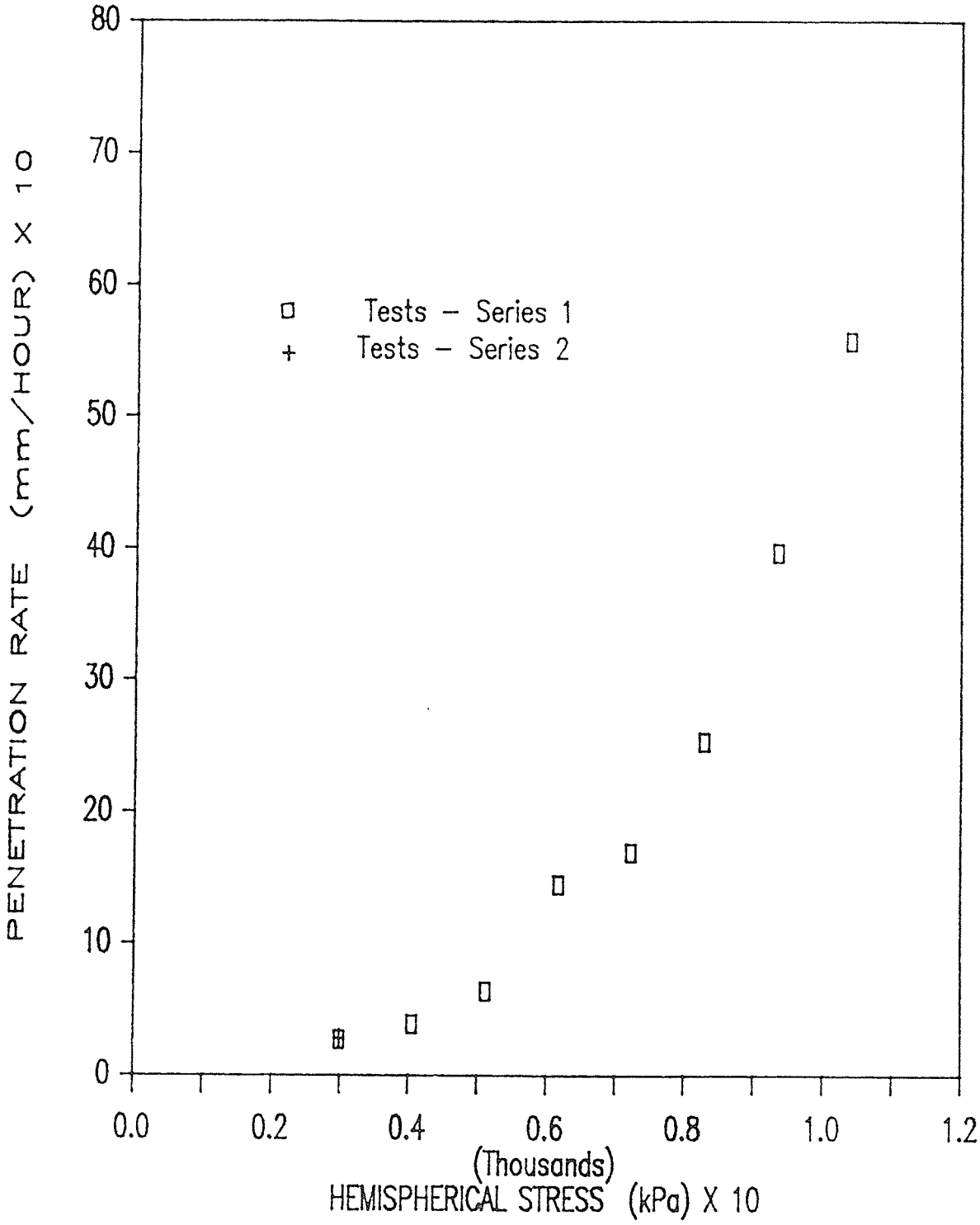

Figure 8.6 Penetration rate versus hemispherical stress (Tests – Series 1 and Series 2)

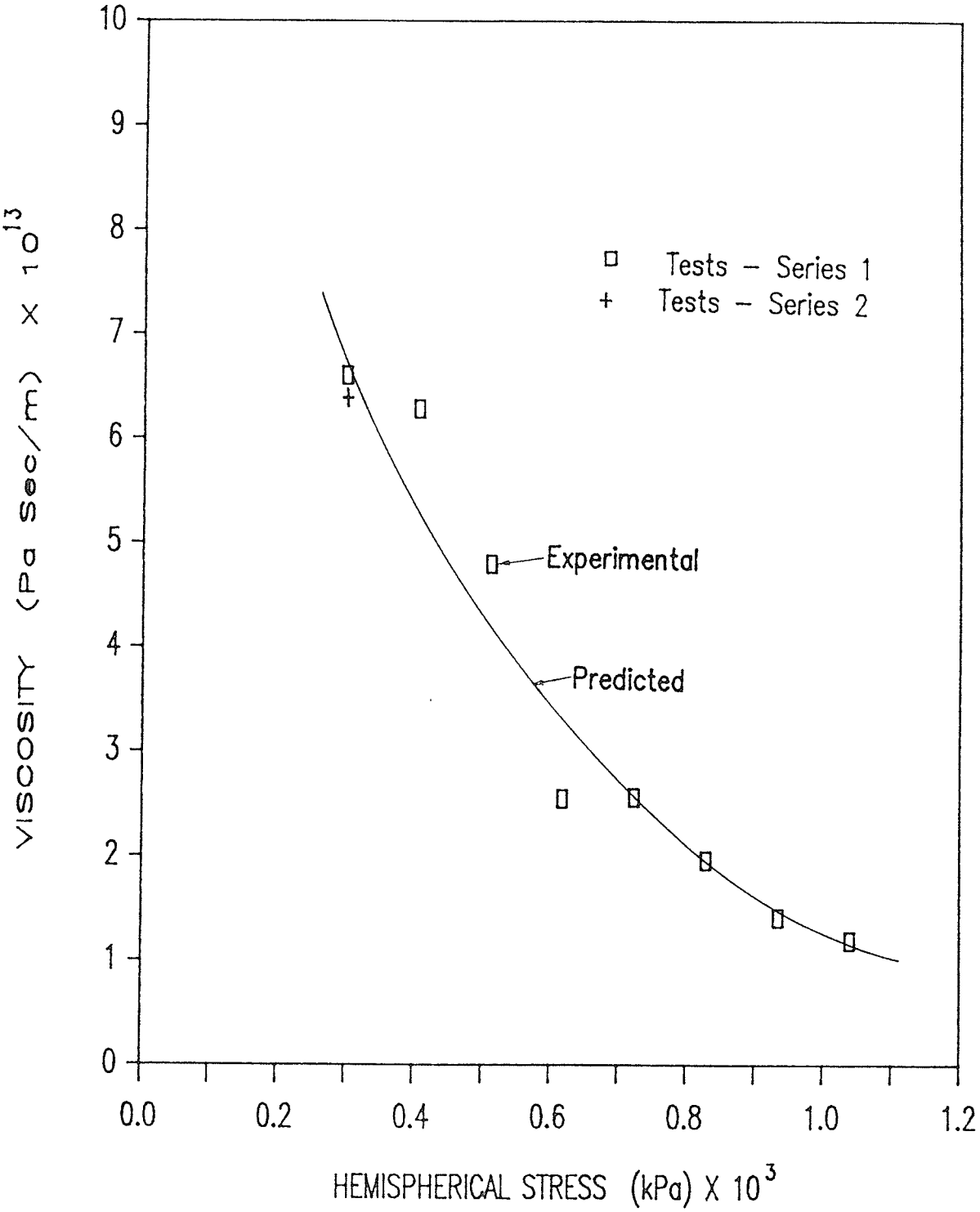

Figure 8.7 Viscosity of polycrystalline ice versus hemispherical stress

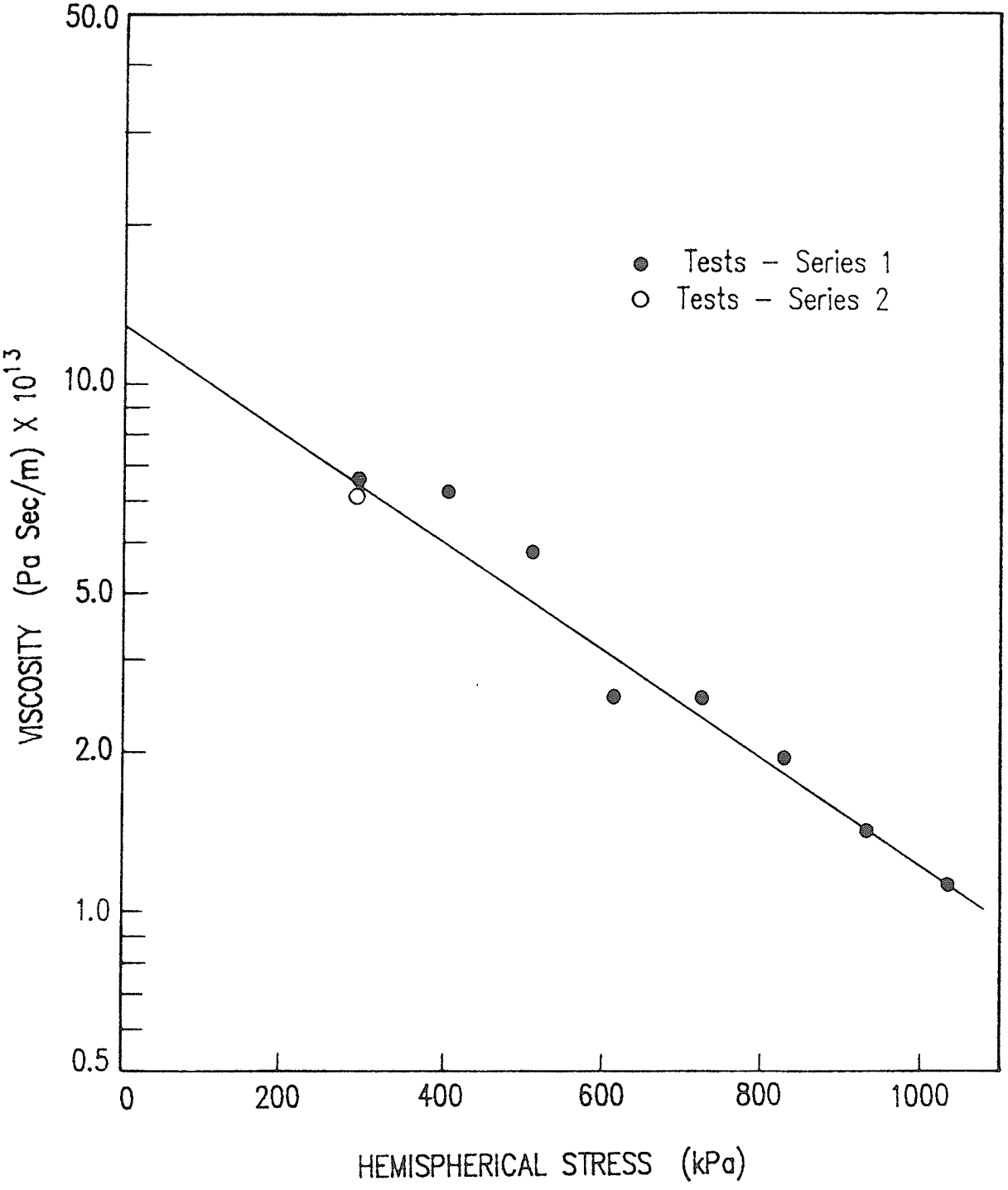

Figure 8.8 Viscosity of polycrystalline ice versus hemispherical stress (semi–log scale)

CHAPTER NINE
CONCLUSIONS AND RECOMMENDATIONS

CHAPTER 9

CONCLUSIONS AND RECOMMENDATIONS

9.1 CONCLUSIONS

The investigation was undertaken to study the creep behaviour of frozen sand subjected to a general state of stress. The study was divided into the following phases and the observations and conclusions are listed for each phase.

1. Creep behaviour under isotropic stress
2. Creep behaviour under deviatoric stress
3. Verification of proposed creep model
4. Comparison of long and short-term triaxial compression tests
5. Interaction of ice and rigid particles

9.1.1 Creep Behaviour under Isotropic Stress

Multi-stage isotropic creep tests were undertaken to study the relationship between the volumetric stress, volumetric strain and time with the temperature kept constant. From the results of the investigation the following observations were drawn:

1. At each stress level there was an instantaneous volumetric

strain followed by time dependent volumetric strain, the rate of which decreased with time to a zero creep rate. Most of the instantaneous strain occurred during the first increment.

2. The time for complete attenuation increased exponentially with an increase in isotropic stress.

3. When the sample was unloaded at the end of isotropic compression, the recovery was immeasurable, indicating that all the strains were inelastic compression.

4. The relationship between the attenuated volumetric strain and the mean normal stress was approximately linear for the stress range investigated. The slope provided an ultimate bulk modulus which was 10,250 kPa for the frozen sand tested at a temperature of -3°C.

5. A model for bulk creep function was developed and expressed as a function of time and mean normal stress as follows:

$$K_c = K_o \left[1 + (1/K_o)\, e^{-mt}\, \sigma_m\right]^2$$

6. The bulk creep function, K_c, increased exponentially with an increase in mean normal stress and decreased hyperbolically with time.

9.1.2 Creep Behaviour under Deviatoric Stress

Constant mean normal stress multi-stage triaxial creep tests were performed to study the creep behaviour under changes in deviatoric stress. From the results of tests the following observations were drawn:

1. The samples underwent volume change during shear deformation, contrary to the belief that the creep deformation of frozen soil occurs at constant volume.

2. Up to a certain stress level the samples underwent attenuating creep and at higher stress levels the samples underwent accelerating creep.

3. The time for complete attenuation increased with an increase in mean normal stress.

4. For a given magnitude of deviatoric stress the volumetric strain decreased with an increase in mean normal stress.

5. The deviatoric stress at which samples began to dilate coincided with the stress at which accelerating creep first occurred. This stress was taken to be the failure stress.

6. The relationship between the deviatoric stress at failure and the mean normal stress was approximately linear and was expressed as follows:

$$S_{df} = S_o + m\sigma_m$$

7. The axial strain at which the failure occurred increased with an increase in mean normal stress.

8. A model for shear creep function expressed as a function of time, mean normal stress and deviatoric stress had the following form:

$$G_c = [m_1\sigma_m^{\beta}\, t^n + ct^{\alpha}\, (S_d/\sigma_m)]^{-1}$$

9. The shear creep function, G_c, increased hyperbolically with an increase in mean normal stress, decreased exponentially with an increase in deviatoric stress, and decreased exponentially with time.

9.1.3 Verification of the Creep Models

Creep models were developed separately for hydrostatic and deviatoric stress changes. The validity of the models was examined by performing multi-stage constant cell pressure triaxial compression tests which involved concurrent changes in the hydrostatic and deviatoric components of stress. The assesment of the models was made by calculating the axial deformation based on the creep models and comparing the calculated values with the measured values. This was

done for time dependent strains and attenuated strains independently. The agreement between the predicted and experimental time dependent strains was quite good considering the scatter that was inherent in all test data. The theoretical attenuated axial deformations agreed well with the observed values. The correlation coefficient was found to be 0.85.

9.1.4 Comparison of Long and Short-term Tests

A series of short-term (loading duration 24 hours or less) constant mean normal stress triaxial compression tests were performed to determine whether the onset of dilation was a stress or strain dependent phenomenon. The stresses were identical to those used in the long-term tests. The following observations were made:

1. The deviatoric stresses corresponding to the onset of dilation were higher in the short term tests than those in the long-term tests.

2. The axial strains at the onset of dilation were lower in the short-term tests than those in the long-term tests.

3. The results suggested that the onset of dilation was neither singly a strain nor a stress phenomena but was influenced by both.

9.1.5 Interaction of Ice and Rigid Particles

The interaction of ice and rigid particles was studied by observing the penetration of rigid steel spheres into ice. For a variety of loads the following observations were made:

1. The relationship between penetration and time was essentially linear for each hemispherical stress which was calculated on the basis of the hemispherical area and the applied load. The hemispherical stress ranged from 300 to 1000 kpa.

2. A relationship between the penetration rate and the hemispherical stress was represented by the following power law:

$$\dot{S} = \dot{S}_o \, (\sigma/\sigma_o)^n$$

3. The penetration rate increased exponentially with an increase in hemispherical stress.

4. A relationship between the viscosity of the polycrystalline ice and the hemispherical stress was represented by the following exponential function.

$$\eta = me^{-n\sigma}$$

5. The viscosity of the polycrystalline ice decreased exponentially with an increase in hemispherical stress.

6. The penetration rate depended on the hemispherical stress and was independent of the size of the spheres.

9.2 RECOMMENDATIONS

The study was limited to quartz carbonate sand and a temperature of -3°C. Thus the models developed for the bulk and shear creep functions did not include parameters representing material type and temperature. The following suggestions are made with regard to an extension of the work undertaken.

1. The study should include different material types and temperature variations to obtain a more general model.

2. Higher stresses should be used to obtain complete stress-strain curves for lower elapsed times.

3. The effect of single-step and multi-step loading on the creep behaviour should be investigated.

4. The interaction of soil particles and ice should be studied with rigid particles having shapes other than spheres to study the effects of particle shape.

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APPENDIX

GEOTECHNICAL LABORATORIES
DEPARTMENT OF CIVIL ENGINEERING
UNIVERSITY OF MANITOBA

ISOTROPIC CONSOLIDATION MULTI-STAGE TRIAXIAL CREEP TEST

IC1 – $\bar{\sigma}m$=50 to 300 kPa

LOAD INCREMENT = 1

CONFINING PRESSURE = 50.0 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (MM/HR)	TRUE AXIAL STRAIN %	VOLUMETRIC STRAIN %	LOG TIME HOUR	CUMULATIVE TIME (HRS)	VOL.STRAIN RATE/HR	LOGSTR RTE/HR
0.0	2.000	0.020	0.665E-02	0.013	0.212	-1.899	0.0	0.106E+00	-0.974
0.2	2.200	0.030	0.370E-03	0.020	0.242	-0.699	0.2	0.165E-02	-2.782
0.5	2.300	0.030	0.0	0.020	0.256	-0.301	0.5	0.486E-03	-3.314
1.0	2.350	0.020	-0.133E-03	0.013	0.263	0.0	1.0	0.135E-03	-3.871
2.0	2.400	0.030	0.666E-04	0.020	0.271	0.301	2.0	0.786E-04	-4.105
6.0	2.600	0.030	0.0	0.020	0.300	0.778	6.0	0.729E-04	-4.137
24.0	3.200	0.030	0.0	0.020	0.388	1.380	24.0	0.486E-04	-4.313
48.0	3.700	0.040	0.277E-05	0.027	0.461	1.681	48.0	0.308E-04	-4.514
82.0	4.200	0.050	0.198E-05	0.033	0.535	1.914	82.0	0.218E-04	-4.885
89.0	4.400	0.050	0.0	0.033	0.564	1.996	89.0	0.172E-04	-4.764
121.0	4.700	0.050	0.0	0.033	0.606	2.083	121.0	0.199E-04	-4.701
145.0	4.800	0.050	0.0	0.033	0.622	2.161	145.0	0.610E-05	-5.215
168.8	4.950	0.060	0.280E-05	0.040	0.645	2.227	168.8	0.945E-05	-5.024
182.8	5.100	0.060	0.0	0.040	0.667	2.285	192.8	0.915E-05	-5.038
216.8	5.300	0.060	0.0	0.040	0.698	2.336	216.8	0.122E-04	-4.914
247.0	5.350	0.060	0.0	0.040	0.704	2.393	247.0	0.243E-05	-5.615
271.5	5.400	0.040	-0.543E-05	0.027	0.710	2.434	271.5	0.252E-05	-5.598
289.0	5.450	0.040	0.0	0.027	0.717	2.461	289.0	0.416E-05	-5.380
313.5	5.500	0.040	0.0	0.027	0.724	2.496	313.5	0.298E-05	-5.524

LOAD INCREMENT = 2

CONFINING PRESSURE = 100.0 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (MM/HR)	TRUE AXIAL STRAIN %	VOLUMETRIC STRAIN %	LOG TIME HOUR	CUMULATIVE TIME (HRS)	VOL.STRAIN RATE/HR	LOGSTR RTE/HR
0.0	5.800	0.220	0.732E-01	0.146	0.735	-1.699	313.5	0.367E+00	-0.435
0.1	5.900	0.210	-0.111E-02	0.140	0.749	-1.097	313.6	0.236E-02	-2.629
0.3	5.900	0.210	0.0	0.140	0.749	-0.301	313.7	0.0	-3.314
0.5	5.950	0.210	0.0	0.140	0.756	-0.301	314.0	0.293E-03	-3.533
2.8	6.100	0.200	-0.298E-04	0.133	0.777	0.439	316.2	0.950E-04	-4.022
7.5	6.200	0.210	0.140E-04	0.140	0.793	0.875	321.0	0.321E-04	-4.494
23.5	6.350	0.210	0.0	0.140	0.815	1.371	337.0	0.137E-04	-4.862
47.0	6.550	0.210	0.0	0.140	0.844	1.672	360.5	0.125E-04	-4.904
71.5	6.700	0.210	0.0	0.140	0.866	1.854	385.0	0.898E-05	-5.047
103.5	7.000	0.210	0.0	0.140	0.910	2.015	417.0	0.137E-04	-4.862
124.5	7.100	0.210	0.0	0.140	0.924	2.095	438.0	0.897E-05	-5.156
167.5	7.200	0.200	-0.155E-05	0.133	0.938	2.224	481.0	0.328E-05	-5.484
191.5	7.450	0.200	0.0	0.133	0.975	2.282	505.0	0.153E-04	-4.816
216.0	7.400	0.200	0.0	0.133	0.968	2.285	528.5	-0.313E-05	-5.038
216.5	7.400	0.210	0.444E-04	0.140	0.969	2.335	530.0	0.385E-05	-5.414

CONFINING PRESSURE = 150.0 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (MM/HR)	TRUE AXIAL STRAIN %	VOLUMETRIC STRAIN %	LOG TIME HOUR	CUMULATIVE TIME (HRS)	VOL.STRAIN RATE/HR	LOGSTR RTE/HR
0.0	7.550	0.230	0.765E-01	0.163	0.970	-1.889	530.0	0.485E+00	-0.314
0.1	7.500	0.260	0.333E-02	0.173	0.979	-1.097	530.1	0.150E-02	-2.823
0.3	7.600	0.250	-0.382E-03	0.166	0.978	-0.301	530.2	-0.336E-04	-3.314
0.6	7.650	0.250	0.0	0.166	0.985	-0.222	530.5	0.210E-03	-3.678
2.5	7.700	0.260	0.351E-04	0.173	0.993	0.398	532.5	0.417E-04	-4.380
4.0	7.750	0.260	0.0	0.173	1.001	0.602	534.0	0.490E-04	-4.310
7.0	7.850	0.260	0.0	0.173	1.015	0.845	537.0	0.488E-04	-4.311
23.0	8.100	0.260	0.0	0.173	1.052	1.362	553.0	0.229E-04	-4.639
53.5	8.300	0.280	0.0	0.173	1.081	1.728	583.5	0.863E-05	-5.016
76.0	8.500	0.280	0.0	0.173	1.111	1.881	606.0	0.131E-04	-4.884
95.0	8.600	0.270	0.360E-05	0.180	1.126	1.978	625.0	0.803E-05	-5.096
118.5	8.750	0.270	0.0	0.180	1.148	2.077	648.5	0.901E-05	-5.045
143.0	8.800	0.270	0.0	0.180	1.156	2.155	673.0	0.312E-05	-5.507
167.0	9.000	0.270	0.0	0.180	1.185	2.223	697.0	0.123E-04	-4.911
191.0	9.150	0.270	0.0	0.180	1.207	2.281	721.0	0.819E-05	-5.087
222.0	9.200	0.270	0.0	0.180	1.214	2.346	752.0	0.238E-05	-5.624
242.0	9.220	0.270	0.0	0.180	1.217	2.384	772.0	0.147E-05	-5.832
262.8	9.350	0.270	0.0	0.180	1.236	2.420	792.8	0.818E-05	-5.087
287.0	9.400	0.270	0.0	0.180	1.244	2.458	817.0	0.304E-05	-5.517
311.0	9.500	0.270	0.0	0.180	1.259	2.493	841.0	0.614E-05	-5.212
334.5	9.500	0.270	0.0	0.180	1.259	0.800	864.5	0.0	1.000
359.0	9.650	0.270	0.0	0.180	1.281	2.555	889.0	0.901E-05	-5.045
380.5	9.750	0.270	0.0	0.180	1.295	2.592	920.5	0.468E-05	-5.330
413.5	9.900	0.270	0.0	0.180	1.317	2.616	943.5	0.980E-05	-5.010
431.0	10.000	0.270	0.0	0.180	1.332	2.634	961.0	0.843E-05	-5.074
460.3	10.050	0.270	0.0	0.180	1.339	2.663	990.3	0.250E-05	-5.602
478.8	10.100	0.270	0.0	0.180	1.347	2.680	1008.8	0.388E-05	-5.399
503.0	10.100	0.270	0.0	0.180	1.347	0.0	1033.0	0.0	0.0
527.5	10.150	0.270	0.0	0.180	1.354	2.722	1057.5	0.301E-05	-5.522

LOAD INCREMENT = 4

CONFINING PRESSURE = 200.0 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (MM/HR)	TRUE AXIAL STRAIN %	VOLUMETRIC STRAIN %	LOG TIME HOUR	CUMULATIVE TIME (HRS)	VOL.STRAIN RATE/HR	LOGSTR RTE/HR
0.1	10.300	0.300	0.250E-01	0.200	1.348	-1.087	1057.6	0.169E+00	-0.773
0.3	10.300	0.300	0.0	0.200	1.348	-1.087	1057.7	0.0	-2.823
0.5	10.300	0.280	-0.286E-03	0.193	1.348	-0.301	1058.0	-0.232E-04	-3.314
1.0	10.300	0.280	0.0	0.193	1.348	-0.222	1058.5	0.0	-3.678
4.0	10.400	0.280	-0.222E-04	0.186	1.362	0.602	1061.5	0.472E-04	-4.326
7.5	10.450	0.280	0.0	0.186	1.370	0.875	1065.0	0.210E-04	-4.678
31.5	10.500	0.280	0.0	0.186	1.377	1.498	1089.0	0.307E-05	-5.512
51.0	10.650	0.280	0.0	0.186	1.398	1.708	1108.5	0.113E-04	-4.945
71.5	10.800	0.290	0.325E-05	0.193	1.422	1.854	1128.0	0.111E-04	-4.956
80.0	10.850	0.290	0.0	0.193	1.429	1.903	1137.5	0.869E-05	-5.061
95.5	10.900	0.290	0.0	0.193	1.436	1.980	1153.0	0.478E-05	-5.322
119.5	10.950	0.290	0.0	0.193	1.444	2.077	1177.0	0.308E-05	-5.514
143.5	11.200	0.290	0.0	0.193	1.481	2.157	1201.0	0.154E-04	-4.814
167.5	11.200	0.290	0.0	0.193	1.481	2.223	1225.0	0.0	-4.811
196.5	11.300	0.290	0.0	0.193	1.495	2.291	1253.0	0.527E-05	-5.278
225.0	11.400	0.280	0.0	0.193	1.510	2.352	1282.5	0.501E-05	-5.300
238.5	11.500	0.280	-0.459E-05	0.186	1.524	2.378	1297.0	0.977E-05	-5.010
263.5	11.800	0.280	0.0	0.186	1.539	2.421	1321.0	0.618E-05	-5.211
287.5	11.700	0.280	0.0	0.186	1.554	2.459	1345.0	0.614E-05	-5.212
311.5	11.750	0.280	0.0	0.186	1.561	2.493	1369.0	0.308E-05	-5.511
335.5	11.800	0.280	0.0	0.186	1.568	2.526	1393.0	0.308E-05	-5.512
360.5	11.900	0.280	0.0	0.186	1.583	2.557	1418.0	0.591E-05	-5.228
388.0	12.000	0.280	0.0	0.186	1.598	2.589	1445.5	0.538E-05	-5.271
414.0	12.020	0.280	0.0	0.186	1.601	2.617	1471.5	0.114E-05	-5.944
440.0	12.050	0.280	0.0	0.186	1.606	2.643	1497.5	0.171E-05	-5.768
458.0	12.180	0.280	0.0	0.186	1.625	2.661	1515.5	0.107E-04	-4.972
464.0	12.200	0.280	0.0	0.186	1.628	2.685	1541.5	0.114E-05	-5.944
511.5	12.300	0.280	0.0	0.186	1.642	2.709	1589.0	0.538E-05	-5.269
535.5	12.300	0.280	0.0	0.186	1.642	2.722	1594.0	0.0	-5.522
559.5	12.450	0.280	0.0	0.186	1.665	2.748	1617.0	0.963E-05	-5.016
583.5	12.500	0.280	0.0	0.186	1.672	2.786	1641.0	0.308E-05	-5.511
599.5	12.550	0.280	0.0	0.186	1.694	2.778	1657.0	0.139E-04	-4.858
623.5	12.700	0.280	0.0	0.186	1.702	2.795	1681.0	0.307E-05	-5.513
647.5	12.800	0.280	0.0	0.186	1.716	2.811	1705.0	0.817E-05	-5.210
678.5	12.900	0.280	0.0	0.186	1.731	2.832	1736.0	0.477E-05	-5.321
698.5	12.900	0.280	0.0	0.186	1.731	0.0	1755.0	0.0	0.0
719.5	13.000	0.280	0.0	0.186	1.746	2.857	1777.0	0.703E-05	-5.153
744.5	13.100	0.280	0.0	0.186	1.761	2.872	1802.0	0.592E-05	-5.227
767.5	13.100	0.280	0.0	0.186	1.761	0.0	1825.0	0.0	0.0
791.5	13.200	0.280	0.0	0.186	1.776	2.898	1849.0	0.615E-05	-5.211
815.5	13.200	0.280	0.0	0.186	1.776	0.0	1873.0	0.0	0.0
847.5	13.300	0.280	0.0	0.186	1.790	2.928	1905.0	0.463E-05	-5.335
867.5	13.300	0.280	0.0	0.186	1.790	0.0	1925.0	0.0	0.0
887.5	13.400	0.280	0.0	0.186	1.805	2.948	1945.0	0.741E-05	-5.130
911.5	13.500	0.280	0.0	0.186	1.820	2.980	1969.0	0.618E-05	-5.211
935.5	13.500	0.280	0.0	0.186	1.820	0.0	1993.0	0.0	0.0
961.5	13.600	0.280	0.0	0.186	1.835	2.983	2019.0	0.570E-05	-5.244
983.5	13.600	0.280	0.0	0.186	1.835	0.0	2041.0	0.0	0.0
1014.5	13.700	0.280	0.0	0.186	1.850	3.006	2072.0	0.477E-05	-5.322
1035.0	13.700	0.280	0.0	0.186	1.850	0.0	2092.5	0.0	0.0
1055.5	13.800	0.280	0.0	0.186	1.864	3.023	2113.0	0.723E-05	-5.141
1079.5	13.800	0.280	0.0	0.186	1.878	3.033	2137.0	0.618E-05	-5.209
1103.5	13.900	0.280	0.0	0.186	1.879	0.0	2161.0	0.0	0.0
1127.5	14.000	0.280	0.0	0.186	1.884	3.052	2185.0	0.616E-05	-5.210
1151.5	14.000	0.280	0.0	0.186	1.884	0.0	2209.0	0.0	0.0
1176.5	14.050	0.280	0.0	0.186	1.901	3.071	2234.0	0.298E-05	-5.528
1202.5	14.100	0.280	0.0	0.186	1.909	3.080	2260.0	0.285E-05	-5.545
1223.5	14.200	0.280	0.0	0.186	1.924	3.088	2281.0	0.704E-05	-5.152
1247.5	14.200	0.280	0.0	0.186	1.924	0.0	2305.0	0.0	0.0

LOAD INCREMENT = 5

CONFINING PRESSURE = 300.0 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (MM/HR)	TRUE AXIAL STRAIN %	VOLUMETRIC STRAIN %	LOG TIME HOUR	CUMULATIVE TIME (HRS)	VOL.STRAIN RATE/HR	LOGSTR RTE/HR
0.2	14.400	0.980	0.408E-01	0.654	1.959	-0.786	2305.2	0.122E+00	-0.912
0.3	14.400	0.980	0.0	0.654	1.959	-1.097	2305.2	0.0	-2.823
0.5	14.500	0.980	0.0	0.654	1.974	-0.301	2305.5	0.594E-03	-3.227
1.3	14.500	0.980	0.0	0.654	1.974	-0.222	2306.2	0.0	-3.678
2.3	14.500	0.980	0.0	0.654	1.974	0.602	2307.2	0.0	-4.326
4.3	14.600	0.980	0.0	0.654	1.989	0.628	2309.2	0.740E-04	-4.131
7.5	14.700	0.980	0.0	0.654	2.004	0.875	2312.5	0.457E-04	-4.340
23.0	14.900	0.980	0.0	0.654	2.034	1.362	2328.0	0.191E-04	-4.718
47.0	15.100	0.980	0.0	0.654	2.063	1.672	2352.0	0.124E-04	-4.908
71.0	15.350	0.980	0.0	0.654	2.100	1.851	2376.0	0.165E-04	-4.811
103.0	15.600	0.980	0.0	0.654	2.137	2.013	2408.0	0.118E-04	-4.936
121.0	15.800	0.980	0.0	0.654	2.167	2.083	2426.0	0.165E-04	-4.783
143.0	15.900	0.980	0.0	0.654	2.182	2.155	2448.0	0.678E-05	-5.170
167.0	16.000	0.980	0.0	0.654	2.197	2.223	2472.0	0.620E-05	-5.208
191.0	16.100	0.980	0.0	0.654	2.212	2.281	2496.0	0.618E-05	-5.209
215.0	16.200	0.980	0.0	0.654	2.227	2.332	2520.0	0.620E-05	-5.208
239.0	16.300	0.980	0.0	0.654	2.241	2.378	2544.0	0.618E-05	-5.209
264.0	16.400	0.980	0.0	0.654	2.256	2.422	2568.0	0.595E-05	-5.225
280.5	16.500	0.980	0.0	0.654	2.271	2.483	2585.5	0.582E-05	-5.251
311.0	16.600	0.980	0.0	0.654	2.288	2.493	2616.0	0.724E-05	-5.140
335.0	16.750	0.980	0.0	0.654	2.308	2.525	2640.0	0.930E-05	-5.031
359.0	16.820	0.980	0.0	0.654	2.319	2.555	2664.0	0.433E-05	-5.384
383.0	16.900	0.980	0.0	0.654	2.331	2.583	2688.0	0.498E-05	-5.304
407.0	17.100	0.980	0.0	0.654	2.360	2.610	2712.0	0.124E-04	-4.907
432.0	17.100	0.980	0.0	0.654	2.360	2.643	2737.0	0.0	-5.788
461.0	17.200	0.980	0.0	0.654	2.375	2.664	2766.0	0.514E-05	-5.289
479.0	17.250	0.980	0.0	0.654	2.383	2.680	2784.0	0.414E-05	-5.383
503.0	17.300	0.980	0.0	0.654	2.390	2.702	2808.0	0.309E-05	-5.510
527.0	17.300	0.980	0.0	0.654	2.390	2.722	2832.0	0.0	-5.522
551.0	17.350	0.980	0.0	0.654	2.398	2.741	2856.0	0.310E-05	-5.508
575.0	17.400	0.980	0.0	0.654	2.405	2.760	2880.0	0.310E-05	-5.508
601.0	17.550	0.980	0.0	0.654	2.427	2.779	2906.0	0.859E-05	-5.066
624.0	17.600	0.980	0.0	0.654	2.435	2.795	2929.0	0.324E-05	-5.490
647.0	17.700	0.980	0.0	0.654	2.450	2.811	2952.0	0.648E-05	-5.188
671.0	17.800	0.980	0.0	0.654	2.465	2.827	2976.0	0.620E-05	-5.208
695.0	17.900	0.980	0.0	0.654	2.480	2.842	3000.0	0.621E-05	-5.207
719.0	17.900	0.980	0.0	0.654	2.480	2.857	3024.0	0.0	-5.153
743.0	18.000	0.680	-0.836E-04	0.453	2.477	2.872	3048.0	-0.101E-05	-5.227
769.0	18.000	0.680	0.0	0.453	2.477	0.0	3074.0	0.0	0.0
793.0	18.100	0.680	0.0	0.453	2.492	2.899	3098.0	0.620E-05	-5.208
815.0	18.200	0.680	0.0	0.453	2.507	2.911	3120.0	0.678E-05	-5.169
839.0	18.300	0.680	0.0	0.453	2.522	2.924	3144.0	0.622E-05	-5.206
863.0	18.300	0.680	0.0	0.453	2.522	0.0	3168.0	0.0	0.0
887.0	18.350	0.680	0.0	0.453	2.529	2.948	3192.0	0.309E-05	-5.510
911.0	18.400	0.680	0.0	0.453	2.537	2.960	3216.0	0.311E-05	-5.507
936.0	18.500	0.680	0.0	0.453	2.552	2.971	3241.0	0.597E-05	-5.224
960.0	18.500	0.680	0.0	0.453	2.552	2.983	3265.0	0.0	-5.244
983.0	18.600	0.680	0.0	0.453	2.566	2.993	3288.0	0.647E-05	-5.189
1007.0	18.600	0.680	0.0	0.453	2.566	3.006	3312.0	0.0	-5.322
1031.0	18.750	0.680	0.0	0.453	2.589	3.013	3336.0	0.833E-05	-5.080
1055.0	18.800	0.680	0.0	0.453	2.596	3.023	3360.0	0.311E-05	-5.507
1029.0	18.850	0.680	0.0	0.453	2.604	3.033	3334.0	-0.288E-05	-5.209
1104.0	18.900	0.680	0.0	0.453	2.611	3.043	3409.0	0.998E-05	-5.002
1132.0	18.900	0.680	0.0	0.453	2.611	3.052	3437.0	0.0	-5.210
1151.0	18.900	0.680	0.0	0.453	2.611	0.0	3456.0	0.0	0.0
1175.0	19.000	0.680	0.0	0.453	2.626	3.070	3480.0	0.622E-05	-5.206
1199.0	19.000	0.680	0.0	0.453	2.626	3.080	3504.0	0.0	-5.545
1223.0	19.100	0.680	0.0	0.453	2.641	3.087	3528.0	0.621E-05	-5.207
1247.0	18.100	0.880	0.0	0.453	2.641	0.0	3552.0	0.0	0.0
1272.0	19.200	0.680	0.0	0.453	2.656	3.104	3577.0	0.598E-05	-5.224
1296.0	19.270	0.680	0.0	0.453	2.666	3.113	3601.0	0.438E-05	-5.361
1319.0	19.300	0.680	0.0	0.453	2.671	3.120	3624.0	0.185E-05	-5.710
1343.0	19.350	0.680	0.0	0.453	2.678	3.128	3648.0	0.310E-05	-5.508
1367.0	19.400	0.680	0.0	0.453	2.686	3.136	3672.0	0.311E-05	-5.507
1391.0	19.450	0.680	0.0	0.453	2.693	3.143	3696.0	0.311E-05	-5.507
1415.0	19.500	0.680	0.0	0.453	2.701	3.151	3720.0	0.312E-05	-5.506
1440.0	19.800	0.680	0.0	0.453	2.716	3.158	3745.0	0.598E-05	-5.225
1464.0	19.850	0.680	0.0	0.453	2.723	3.167	3773.0	0.267E-05	-5.573
1487.0	19.700	0.680	0.0	0.453	2.731	3.172	3792.0	0.393E-05	-5.405
1512.0	19.800	0.680	0.0	0.453	2.746	3.180	3817.0	0.598E-05	-5.223
1535.0	19.800	0.680	0.0	0.453	2.746	0.0	3840.0	0.0	0.0
1559.0	19.850	0.680	0.0	0.453	2.753	3.193	3864.0	0.310E-05	-5.509
1588.0	19.900	0.680	0.0	0.453	2.761	3.201	3893.0	0.258E-05	-5.588
1608.5	19.900	0.680	0.0	0.453	2.761	0.0	3913.5	0.0	0.0
1633.0	19.920	0.680	0.0	0.453	2.764	3.213	3938.0	0.122E-05	-5.914
1655.0	19.900	0.680	0.0	0.453	2.761	0.0	3960.0	-0.136E-05	0.0
1679.0	20.000	0.680	0.0	0.453	2.775	3.225	3984.0	0.623E-05	-5.205
1703.0	20.100	0.680	0.0	0.453	2.790	3.231	4008.0	0.622E-05	-5.206
1727.0	20.150	0.680	0.0	0.453	2.798	3.237	4032.0	0.312E-05	-5.506
1751.0	20.200	0.680	0.0	0.453	2.805	3.243	4056.0	0.312E-05	-5.506
1777.0	20.300	0.680	0.0	0.453	2.820	3.250	4082.0	0.576E-05	-5.240
1808.0	20.250	0.680	0.0	0.453	2.813	0.0	4113.0	-0.241E-05	0.0
1823.0	20.300	0.680	0.0	0.453	2.820	3.261	4128.0	0.488E-05	-5.302
1847.0	20.400	0.680	0.0	0.453	2.835	3.268	4152.0	0.622E-05	-5.206
1871.0	20.450	0.680	0.0	0.453	2.843	3.272	4176.0	0.312E-05	-5.506
1895.0	20.500	0.680	0.0	0.453	2.850	3.278	4200.0	0.312E-05	-5.506
1819.0	20.600	0.680	0.0	0.453	2.865	0.0	4124.0	-0.197E-05	0.0
1944.5	20.650	0.680	0.0	0.453	2.873	3.289	4249.5	0.586E-05	-5.225
1972.0	20.700	0.680	0.0	0.453	2.880	3.295	4277.0	0.272E-05	-5.565
1991.0	20.700	0.680	0.0	0.453	2.880	0.0	4296.0	0.0	0.0
2019.0	20.700	0.680	0.0	0.453	2.880	0.0	4324.0	0.0	0.0
2039.0	20.800	0.680	0.0	0.453	2.895	3.309	4344.0	0.748E-05	-5.126
2063.0	20.800	0.680	0.0	0.453	2.895	0.0	4368.0	0.0	0.0
2087.0	20.850	0.680	0.0	0.453	2.903	3.320	4392.0	0.311E-05	-5.508
2112.5	20.900	0.680	0.0	0.453	2.910	3.326	4417.5	0.294E-05	-5.532
2159.0	21.000	0.680	0.0	0.453	2.925	3.334	4464.0	0.322E-05	-5.492

PLOT 1, 1490 UNPLOTTABLE POINTS

GEOTECHNICAL LABORATORIES
DEPARTMENT OF CIVIL ENGINEERING
UNIVERSITY OF MANITOBA

CONSTANT MEAN NORMAL STRESS MULTI-STAGE TRIAXIAL CREEP TEST

MST1 – $\bar{\sigma}m$=140 kPa

LOAD INCREMENT # 1 S.D.= 0 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.4	-1.258	0.021	0.347E-03	0.014	-0.186	0.118	0.4	-3.459	-0.398
4.4	-1.715	0.033	0.216E-04	0.022	-0.253	0.162	4.4	-4.666	0.643
21.0	-2.114	0.031	-0.797E-06	0.021	-0.312	0.203	21.0	0.0	0.0

LOAD INCREMENT # 2 S.D.= 49 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.5	-0.552	0.005	0.720E-04	0.004	-0.082	0.058	0.5	-4.143	-0.301
1.8	-1.450	0.000	-0.254E-04	0.000	-0.215	0.175	1.8	-4.668	0.643
3.3	-2.000	0.000	0.0	0.000	-0.296	0.241	3.3	0.0	0.0

AYLIN EQUATION NUMBER 1

ERROR - INSUFFICIENT DATA POINTS FOR SUBROUTINE AYLIN - CALL IGNORED

LOAD INCREMENT # 3 S.D.= 98 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.3	-2.417	0.148	0.333E-02	0.100	-0.358	0.048	3.6	-2.478	-0.623
5.7	-2.632	0.182	0.417E-04	0.122	-0.380	0.019	9.0	-4.380	0.756
21.3	-2.555	0.234	0.225E-04	0.157	-0.379	0.076	24.6	-4.648	1.328
29.3	-2.901	0.226	-0.662E-05	0.152	-0.430	0.021	32.6	-2.000	0.0
45.2	-2.775	0.278	0.225E-04	0.188	-0.411	0.124	48.5	-4.648	1.855
69.3	-2.975	0.278	0.0	0.188	-0.441	0.100	72.6	0.0	0.0

AYLIN EQUATION NUMBER 2

Y = -1.157086 -1.221094 X -5.270054 X**2 + 2.918693 X**3

T-VALUES ARE 0.8438 1.7696 1.7047

RSQUARE = 0.8421 STD ERR. OF EST. = 1.178848

LOAD INCREMENT # 4 S.D.= 147 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.5	-3.114	0.285	0.344E-02	0.172	-0.462	0.044	73.1	-2.464	-0.301
7.3	-3.169	0.265	0.873E-05	0.178	-0.470	0.053	78.9	-5.012	0.863
23.2	-3.227	0.283	0.748E-05	0.190	-0.478	0.078	95.8	-5.126	1.385
31.3	-3.228	0.284	0.164E-05	0.192	-0.479	0.079	103.9	-5.786	1.496
51.8	-3.332	0.285	0.355E-05	0.199	-0.494	0.084	124.4	-5.448	1.714
73.8	-3.269	0.309	0.422E-05	0.208	-0.485	0.114	146.4	-5.375	1.868
95.2	-3.345	0.324	0.464E-05	0.218	-0.496	0.129	167.8	-5.334	1.979

AYLIN EQUATION NUMBER 3

Y = -3.272538 -2.519612 X + .5598913 X**2 + .9469503E-01 X**3

T-VALUES ARE : 3.4643 0.4131 0.1927
RSQUARE = 0.9741 STD. ERR. OF EST. = .2541397

LOAD INCREMENT # 5 S.D.= 196 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.5	-3.344	0.322	0.433E-02	0.217	-0.496	0.126	168.3	-2.363	-0.301
6.5	-3.354	0.342	0.232E-04	0.231	-0.497	0.159	174.3	-4.635	0.813
23.4	-3.416	0.371	0.114E-04	0.250	-0.507	0.198	191.2	-4.944	1.389
31.1	-3.420	0.380	0.774E-05	0.256	-0.507	0.212	198.9	-5.111	1.493
47.0	-3.381	0.403	0.100E-04	0.272	-0.501	0.255	214.8	-5.000	1.672
54.0	-3.435	0.413	0.948E-05	0.278	-0.508	0.266	221.8	-5.024	1.732
70.0	-3.444	0.432	0.788E-05	0.291	-0.511	0.286	237.8	-5.104	1.845
78.0	-3.487	0.438	0.581E-05	0.296	-0.519	0.300	245.8	-5.236	1.892
94.0	-3.506	0.458	0.828E-05	0.309	-0.520	0.332	261.8	-5.082	1.973

AYLIN EQUATION NUMBER 4

Y = -3.268031 -2.589321 X + 1.312916 X**2 -.2435792 X**3

T-VALUES ARE : 11.8404 3.3184 1.6901
RSQUARE = 0.9947 STD. ERR. OF EST. = .8326187E-01

LOAD INCREMENT # 6 S.D.= 245 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.7	-3.513	0.474	0.458E-02	0.319	-0.521	0.357	262.5	-2.341	-0.155
7.2	-3.538	0.523	0.510E-04	0.352	-0.524	0.435	269.0	-4.292	0.857
29.8	-3.515	0.591	0.205E-04	0.399	-0.521	0.551	291.6	-4.687	1.474
54.2	-3.606	0.683	0.253E-04	0.461	-0.520	0.704	316.0	-4.597	1.734
75.8	-3.435	0.746	0.197E-04	0.503	-0.509	0.817	337.6	-4.706	1.880
95.3	-3.505	0.792	0.160E-04	0.534	-0.520	0.884	357.1	-4.796	1.979

AYLIN EQUATION NUMBER 5

Y = -2.822820 -2.885137 X + 1.600559 X**2 -.3264927 X**3

T-VALUES ARE : 7.8965 2.8240 1.6484
RSQUARE = 0.9967 STD. ERR. OF EST. = .8548972E-01

LOAD INCREMENT # 7 S.D.= 294 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.5	-3.481	0.804	0.109E-01	0.543	-0.516	0.908	357.6	-1.964	-0.301
7.6	-3.492	0.874	0.664E-04	0.590	-0.518	1.022	364.7	-4.178	0.881
23.9	-3.340	0.980	0.441E-04	0.662	-0.495	1.217	381.0	-4.356	1.378
31.5	-3.306	1.015	0.315E-04	0.686	-0.490	1.280	388.6	-4.502	1.498
48.0	-3.194	1.102	0.355E-04	0.744	-0.474	1.437	405.1	-4.450	1.681
72.3	-3.084	1.190	0.247E-04	0.804	-0.457	1.597	429.4	-4.608	1.859
101.4	-2.897	1.331	0.327E-04	0.900	-0.429	1.853	458.5	-4.485	2.006
125.0	-2.742	1.432	0.291E-04	0.968	-0.407	2.040	482.1	-4.536	2.097
144.2	-2.702	1.520	0.313E-04	1.028	-0.401	2.192	501.3	-4.505	2.159
169.2	-2.591	1.653	0.361E-04	1.119	-0.384	2.426	526.3	-4.443	2.228
191.9	-2.488	1.756	0.309E-04	1.189	-0.369	2.611	549.0	-4.510	2.283
216.3	-2.338	1.868	0.315E-04	1.266	-0.347	2.817	573.4	-4.501	2.335
239.5	-2.288	1.979	0.326E-04	1.341	-0.339	3.009	596.6	-4.487	2.379
265.5	-2.223	2.058	0.206E-04	1.395	-0.329	3.148	622.6	-4.686	2.424
297.3	-2.169	2.159	0.217E-04	1.464	-0.321	3.323	654.4	-4.663	2.473
311.8	-2.041	2.209	0.236E-04	1.498	-0.302	3.423	668.9	-4.627	2.494
336.1	-2.026	2.287	0.218E-04	1.551	-0.300	3.554	693.2	-4.661	2.526
360.2	-1.912	2.367	0.228E-04	1.606	-0.283	3.703	717.3	-4.641	2.557
383.9	-1.796	2.442	0.215E-04	1.657	-0.266	3.842	741.0	-4.667	2.584
408.0	-1.717	2.490	0.137E-04	1.690	-0.254	3.932	765.1	-4.865	2.611
433.7	-1.662	2.590	0.267E-04	1.759	-0.246	4.107	790.8	-4.574	2.637
479.9	-1.484	2.750	0.237E-04	1.868	-0.220	4.397	837.0	-4.625	2.681
504.2	-1.366	2.822	0.202E-04	1.918	-0.202	4.532	861.3	-4.694	2.703
528.0	-1.299	2.885	0.212E-04	1.968	-0.192	4.664	885.1	-4.673	2.723
552.0	-1.226	2.956	0.174E-04	2.010	-0.182	4.775	909.1	-4.759	2.742
576.2	-1.158	3.027	0.201E-04	2.058	-0.171	4.902	933.3	-4.698	2.761
601.8	-1.101	3.123	0.258E-04	2.125	-0.163	5.071	958.9	-4.588	2.779
648.3	-0.924	3.284	0.238E-04	2.235	-0.137	5.364	1005.4	-4.623	2.812
671.7	-0.855	3.355	0.208E-04	2.284	-0.127	5.491	1028.8	-4.682	2.827
695.0	-0.741	3.435	0.238E-04	2.339	-0.110	5.641	1052.1	-4.624	2.842
720.5	-0.138	3.539	0.281E-04	2.411	-0.020	5.889	1077.6	-4.551	2.858
743.9	-0.184	3.641	0.301E-04	2.482	-0.027	6.056	1101.0	-4.522	2.872
769.3	-0.196	3.781	0.379E-04	2.578	-0.029	6.291	1126.4	-4.422	2.886
821.0	-0.070	4.056	0.368E-04	2.768	-0.010	6.771	1178.1	-4.435	2.914
840.0	-0.012	4.150	0.343E-04	2.833	-0.002	6.938	1197.1	-4.464	2.924
863.9	0.062	4.319	0.489E-04	2.950	0.009	7.234	1221.0	-4.310	2.936
887.4	0.262	4.431	0.330E-04	3.028	0.039	7.448	1244.5	-4.481	2.948
911.7	0.306	4.555	0.356E-04	3.114	0.045	7.665	1268.8	-4.448	2.960
936.5	0.450	4.680	0.349E-04	3.201	0.066	7.895	1293.6	-4.457	2.972
963.1	0.540	4.815	0.352E-04	3.294	0.080	8.134	1320.2	-4.454	2.984
984.1	0.639	4.928	0.377E-04	3.374	0.094	8.341	1341.2	-4.423	2.993
1008.8	0.767	5.087	0.449E-04	3.484	0.113	8.627	1365.9	-4.348	3.004
1032.5	0.903	5.231	0.422E-04	3.584	0.133	8.889	1389.6	-4.375	3.014
1057.4	0.994	5.361	0.366E-04	3.675	0.147	9.123	1414.5	-4.437	3.024
1082.1	1.085	5.494	0.375E-04	3.768	0.160	9.360	1439.2	-4.426	3.034
1108.9	1.218	5.644	0.392E-04	3.873	0.180	9.634	1466.0	-4.407	3.045
1135.4	1.352	5.789	0.384E-04	3.975	0.200	9.899	1492.5	-4.416	3.055
1154.4	1.452	5.902	0.416E-04	4.054	0.214	10.105	1511.5	-4.381	3.062

AVLIN EQUATION NUMBER 6

Y = -2.651254 -1.963770 X + .5658468 X**2 -.3755079E-01 X**3

T-VALUES ARE : 12.7757 4.4892 1.4157
RSQUARE = 0.9313 STD. ERR. OF EST. = .1062342

LOAD INCREMENT # 8 S.D.= 343 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.6	1.732	5.945	0.681E-01	4.084	0.256	10.213	1512.1	-1.167	-0.222
6.3	2.124	6.076	0.161E-03	4.176	0.314	10.484	1517.8	-3.794	0.799
22.2	2.507	6.336	0.115E-03	4.358	0.370	10.978	1533.7	-3.940	1.346
30.3	2.651	6.460	0.107E-03	4.445	0.391	11.209	1541.8	-3.969	1.481
46.8	2.950	6.687	0.968E-04	4.605	0.435	11.636	1558.3	-4.014	1.670
70.1	3.299	7.023	0.102E-03	4.843	0.487	12.260	1581.6	-3.992	1.846
94.6	3.642	7.373	0.101E-03	5.090	0.537	12.906	1606.1	-3.996	1.976
127.0	4.233	7.839	0.102E-03	5.421	0.624	13.787	1638.5	-3.991	2.104
166.8	4.950	8.468	0.113E-03	5.869	0.730	14.971	1678.3	-3.948	2.222
190.1	5.421	8.867	0.122E-03	6.154	0.799	15.726	1701.6	-3.913	2.278
214.8	5.986	9.280	0.120E-03	6.450	0.881	16.519	1726.3	-3.921	2.332
238.2	6.393	9.711	0.132E-03	6.760	0.941	17.327	1749.7	-3.878	2.377
262.8	6.876	10.194	0.142E-03	7.108	1.012	18.238	1774.3	-3.849	2.420
312.7	7.986	11.174	0.142E-03	7.819	1.174	20.111	1824.2	-3.847	2.495
334.9	8.534	11.625	0.148E-03	8.148	1.254	20.983	1846.4	-3.829	2.525
358.2	9.350	12.257	0.198E-03	8.610	1.374	22.212	1869.7	-3.703	2.554
382.8	9.831	12.746	0.146E-03	8.969	1.444	23.149	1894.3	-3.835	2.583
406.2	10.164	13.118	0.117E-03	9.244	1.492	23.861	1917.7	-3.931	2.609
430.8	10.589	13.508	0.117E-03	9.533	1.554	24.619	1942.3	-3.930	2.634
455.5	11.264	14.343	0.251E-03	10.152	1.652	26.217	1967.0	-3.600	2.658
479.3	11.872	14.771	0.134E-03	10.472	1.741	27.072	1990.8	-3.872	2.681
526.2	12.851	15.487	0.115E-03	11.009	1.854	28.480	2037.7	-3.941	2.721
550.8	13.056	15.921	0.133E-03	11.335	1.913	29.328	2062.3	-3.877	2.741
574.2	13.445	16.280	0.116E-03	11.606	1.969	30.036	2085.7	-3.937	2.759
588.9	13.793	16.619	0.104E-03	11.863	2.020	30.707	2110.4	-3.983	2.777
624.0	14.090	16.960	0.103E-03	12.121	2.063	31.375	2135.5	-3.987	2.795
649.4	14.446	17.280	0.958E-04	12.365	2.114	32.014	2160.9	-4.018	2.813
670.8	14.733	17.533	0.902E-04	12.558	2.156	32.521	2182.3	-4.045	2.827
694.8	15.029	17.877	0.109E-03	12.821	2.199	33.199	2206.3	-3.961	2.842
718.8	15.590	18.298	0.134E-03	13.143	2.280	34.056	2230.3	-3.871	2.857
742.1	15.931	18.651	0.117E-03	13.415	2.329	34.761	2253.6	-3.933	2.870
766.7	16.277	18.995	0.108E-03	13.680	2.379	35.451	2278.2	-3.966	2.885
792.7	16.624	19.337	0.102E-03	13.944	2.429	36.138	2304.2	-3.993	2.899
816.4	16.893	19.628	0.953E-04	14.170	2.483	36.735	2327.9	-4.021	2.912
838.3	17.273	19.895	0.947E-04	14.377	2.523	37.276	2349.8	-4.024	2.923
862.3	18.072	20.121	0.732E-04	14.553	2.638	37.800	2373.8	-4.136	2.936

AVLIN EQUATION NUMBER 7

Y = -2.039707 -3.472120 X + 1.929217 X**2 -.3327643 X**3

T-VALUES ARE : 24.9821 16.3932 12.8933
RSQUARE = 0.9742 STD. ERR. OF EST. = .7907045E-01
PLOT 1, 671 UNPLOTTABLE POINTS

GEOTECHNICAL LABORATORIES
DEPARTMENT OF CIVIL ENGINEERING
UNIVERSITY OF MANITOBA

CONSTANT MEAN NORMAL STRESS MULTI-STAGE TRIAXIAL CREEP TEST
MST2 – σ_m=280 kPa

LOAD INCREMENT # 1 S.D.= 0 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.5	-2.318	0.040	0.540E-03	0.027	-0.341	0.212	0.5	-3.267	-0.301
4.0	-2.356	0.125	0.161E-03	0.083	-0.346	0.078	4.0	-3.792	0.602
21.0	-3.165	0.145	0.782E-05	0.097	-0.485	0.143	21.0	-5.107	1.322
45.5	-6.206	0.237	0.252E-04	0.159	-0.915	0.358	45.5	-4.598	1.658
68.0	-2.972	0.272	0.103E-04	0.182	-0.437	0.089	68.0	-4.985	1.833
76.5	-4.192	0.316	0.352E-04	0.212	-0.617	0.015	76.5	-4.453	1.884
92.5	-3.692	0.316	0.0	0.212	-0.543	0.076	92.5	0.0	0.0
116.5	-3.748	0.329	0.361E-05	0.221	-0.551	0.080	116.5	-5.443	2.066
140.5	-3.912	0.362	0.915E-05	0.243	-0.576	0.124	140.5	-5.039	2.148
164.5	-4.386	0.414	0.147E-04	0.278	-0.646	0.153	164.5	-4.833	2.216
191.5	-4.049	0.444	0.740E-05	0.298	-0.596	0.243	191.5	-5.131	2.282
236.0	-3.905	0.456	0.180E-05	0.306	-0.574	0.260	236.0	-5.745	2.373
260.0	-4.518	0.486	0.833E-05	0.326	-0.665	0.255	260.0	-5.080	2.415
284.0	-4.140	0.536	0.139E-04	0.358	-0.609	0.382	284.0	-4.857	2.453
308.0	-4.843	0.541	0.139E-05	0.362	-0.713	0.306	308.0	-5.858	2.489
330.5	-4.554	0.565	0.741E-05	0.378	-0.670	0.381	330.5	-5.130	2.519
357.0	-5.083	0.630	0.164E-04	0.422	-0.748	0.424	357.0	-4.786	2.553
404.0	-5.464	0.589	-0.582E-05	0.395	-0.805	0.311	404.0	0.0	0.0
428.0	-5.573	0.608	0.528E-05	0.408	-0.821	0.329	428.0	-5.277	2.631
452.0	-5.029	0.622	0.389E-05	0.417	-0.741	0.417	452.0	-5.410	2.655
476.0	-5.636	0.638	0.444E-05	0.428	-0.830	0.370	476.0	-5.352	2.678
500.0	-3.729	0.622	-0.444E-05	0.417	-0.549	0.574	500.0	0.0	0.0
525.5	-3.688	0.643	0.549E-05	0.431	-0.543	0.613	525.5	-5.261	2.721
572.0	-3.911	0.627	-0.229E-05	0.420	-0.575	0.560	572.0	0.0	0.0
596.0	-3.782	0.629	0.556E-06	0.422	-0.556	0.579	596.0	-6.255	2.775

LOAD INCREMENT # 2 S.D.= 98 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
1.8	0.063	0.083	0.311E-03	0.056	0.009	0.145	1.8	-3.507	0.255
7.8	-0.044	0.098	0.167E-04	0.066	-0.007	0.156	7.8	-4.778	0.892
23.3	-0.148	0.110	0.517E-05	0.074	-0.022	0.183	23.3	-5.286	1.367
34.3	-0.108	0.130	0.121E-04	0.087	-0.016	0.201	34.3	-4.916	1.535
47.3	-0.218	0.151	0.108E-04	0.101	-0.032	0.222	47.3	-4.967	1.675
71.1	-0.334	0.187	0.104E-04	0.126	-0.049	0.268	71.1	-4.984	1.852
96.6	-0.494	0.210	0.602E-05	0.141	-0.073	0.287	96.6	-5.220	1.985
123.4	-0.647	0.215	0.125E-05	0.145	-0.095	0.277	123.4	-5.905	2.091
143.4	-0.748	0.218	0.100E-05	0.147	-0.110	0.269	143.4	-5.999	2.157
164.1	-0.852	0.227	0.290E-05	0.153	-0.126	0.272	164.1	-5.537	2.215
188.3	-0.904	0.232	0.138E-05	0.156	-0.133	0.273	188.3	-5.859	2.275
211.4	-1.005	0.234	0.578E-06	0.157	-0.148	0.265	211.4	-6.237	2.325
235.2	-1.106	0.237	0.843E-06	0.159	-0.183	0.257	235.2	-6.074	2.371
259.8	-1.081	0.293	0.152E-04	0.197	-0.160	0.352	259.8	-4.818	2.415
284.3	-1.234	0.299	0.164E-06	0.201	-0.182	0.343	284.3	-5.786	2.454
307.3	-1.437	0.306	0.204E-05	0.206	-0.212	0.330	307.3	-5.691	2.488
333.6	-1.944	0.321	0.407E-05	0.216	-0.287	0.295	333.6	-5.391	2.523
354.9	-1.847	0.328	0.220E-05	0.221	-0.273	0.318	354.9	-5.658	2.550
378.0	-1.850	0.333	0.139E-05	0.224	-0.273	0.326	379.0	-5.858	2.579
403.0	-1.951	0.336	0.834E-06	0.226	-0.288	0.319	403.0	-6.079	2.605
428.3	-1.955	0.345	0.238E-05	0.232	-0.289	0.333	428.3	-5.624	2.632
457.0	-2.052	0.338	-0.163E-05	0.228	-0.303	0.310	457.0	0.0	0.0
475.2	-2.103	0.340	0.732E-06	0.229	-0.311	0.307	475.2	-6.136	2.677

AYLIN EQUATION NUMBER 1

Y = -.6789122 -8.153956 X + 4.700424 X**2 -.8999615 X**3

T-VALUES ARE : 5.2958 3.5886 2.9817

RSQUARE = 0.8776 STD. ERR. OF EST. = .4883730

LOAD INCREMENT # 3 S.D.= 196 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.5	-2.184	0.411	0.553E-02	0.276	-0.323	0.414	475.7	-2.257	-0.301
10.1	-2.173	0.386	-0.174E-04	0.260	-0.321	0.374	485.3	-4.778	0.892
23.8	-2.278	0.398	0.585E-05	0.268	-0.337	0.381	499.0	-5.233	1.377
32.8	-2.332	0.406	0.595E-05	0.273	-0.345	0.387	508.0	-5.225	1.516
47.8	-2.385	0.413	0.312E-05	0.278	-0.352	0.393	523.0	-5.508	1.679
72.0	-2.469	0.422	0.248E-05	0.284	-0.368	0.395	547.2	-5.605	1.857
95.8	-2.495	0.434	0.338E-05	0.292	-0.369	0.414	571.0	-5.472	1.981
121.3	-2.505	0.457	0.630E-05	0.308	-0.370	0.452	596.5	-5.201	2.084
152.5	-2.626	0.459	0.429E-06	0.309	-0.388	0.440	627.7	-6.367	2.183
168.2	-2.713	0.474	0.639E-05	0.319	-0.401	0.455	643.4	-5.194	2.226
192.1	-2.760	0.467	-0.196E-05	0.315	-0.408	0.437	667.3	-5.859	2.275
216.1	-2.814	0.476	0.251E-05	0.321	-0.416	0.446	691.3	-5.600	2.335
240.0	-2.918	0.485	0.252E-05	0.327	-0.431	0.448	715.2	-5.599	2.380
263.8	-2.966	0.481	-0.112E-05	0.324	-0.439	0.435	739.0	-4.818	2.415
295.3	-3.019	0.488	0.149E-05	0.329	-0.446	0.440	770.5	-5.828	2.470
317.5	-3.069	0.487	-0.302E-06	0.328	-0.454	0.433	792.7	-5.691	2.488
336.1	-3.121	0.492	0.180E-05	0.331	-0.461	0.435	811.3	-5.745	2.526
359.1	-3.223	0.498	0.175E-05	0.335	-0.477	0.432	834.3	-5.757	2.555
383.9	-3.622	0.495	-0.813E-06	0.333	-0.536	0.379	859.1	-5.858	2.579
407.8	-3.674	0.500	0.140E-05	0.337	-0.544	0.381	883.0	-5.853	2.610
433.5	-3.678	0.509	0.234E-05	0.343	-0.544	0.395	908.7	-5.630	2.637
463.2	-3.636	0.527	0.408E-05	0.355	-0.538	0.430	938.4	-5.392	2.666
504.1	-3.786	0.526	-0.164E-06	0.354	-0.560	0.410	979.3	-6.136	2.677

AVLIN EQUATION NUMBER 2

Y = -3.164220 -2.691922 X + 1.095951 X**2 - .1687296 X**3

T-VALUES ARE : 4.5294 1.7102 1.0408
RSQUARE = 0.8486 STD. ERR. OF EST. = .3285549

LOAD INCREMENT # 4 S.D.= 294 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.5	-3.736	0.570	0.768E-02	0.384	-0.553	0.490	979.8	-2.115	-0.301
9.0	-3.785	0.568	-0.158E-05	0.383	-0.560	0.480	988.3	-4.778	0.892
23.3	-3.700	0.601	0.155E-04	0.405	-0.547	0.545	1002.6	-4.811	1.367
34.2	-3.810	0.623	0.135E-04	0.420	-0.564	0.568	1013.5	-4.869	1.534
47.6	-3.918	0.641	0.898E-05	0.432	-0.580	0.584	1026.9	-5.046	1.678
71.3	-4.032	0.674	0.833E-05	0.454	-0.597	0.624	1050.6	-5.030	1.853
95.0	-4.142	0.694	0.594E-05	0.468	-0.613	0.646	1074.3	-5.226	1.978
126.1	-4.269	0.755	0.131E-04	0.509	-0.632	0.730	1105.4	-4.861	2.101
149.3	-4.307	0.728	-0.780E-05	0.491	-0.637	0.681	1128.6	-6.367	2.183
167.2	-4.362	0.739	0.412E-05	0.498	-0.646	0.693	1146.5	-5.386	2.223
191.2	-4.472	0.762	0.642E-05	0.513	-0.662	0.717	1170.5	-5.192	2.281
214.8	-4.479	0.779	0.483E-05	0.525	-0.663	0.744	1194.1	-5.316	2.332
240.5	-4.586	0.793	0.365E-05	0.534	-0.678	0.754	1219.8	-5.437	2.381
264.6	-4.587	0.796	0.829E-06	0.536	-0.679	0.759	1244.1	-6.082	2.423
293.8	-4.696	0.817	0.486E-05	0.550	-0.695	0.780	1273.1	-5.314	2.468
313.3	-4.741	0.805	-0.413E-05	0.542	-0.702	0.755	1292.6	-5.691	2.488
335.3	-4.793	0.810	0.152E-05	0.546	-0.710	0.757	1314.6	-5.817	2.525
359.3	-4.897	0.818	0.224E-05	0.551	-0.725	0.758	1338.6	-5.650	2.555
383.3	-4.899	0.821	0.112E-05	0.554	-0.725	0.764	1362.6	-5.952	2.584
407.3	-4.953	0.831	0.279E-05	0.560	-0.733	0.774	1386.6	-5.554	2.610
431.3	-5.004	0.834	0.837E-06	0.562	-0.741	0.772	1410.6	-6.077	2.635
460.7	-5.107	0.840	0.137E-05	0.566	-0.756	0.770	1440.0	-5.863	2.663
479.4	-5.161	0.848	0.287E-05	0.572	-0.764	0.777	1458.7	-5.543	2.681
503.0	-5.265	0.857	0.258E-05	0.578	-0.780	0.778	1482.3	-5.592	2.702
527.3	-5.321	0.872	0.414E-05	0.588	-0.788	0.796	1506.6	-5.383	2.722
551.3	-5.374	0.879	0.186E-05	0.593	-0.796	0.802	1530.6	-5.709	2.741
575.3	-5.428	0.887	0.224E-05	0.598	-0.804	0.808	1554.6	-5.850	2.760
600.2	-5.493	0.920	0.889E-05	0.620	-0.814	0.855	1579.5	-5.051	2.778
634.2	-5.586	0.904	-0.316E-05	0.609	-0.827	0.817	1613.5	0.0	0.0
675.0	-5.426	0.983	0.148E-04	0.670	-0.804	0.984	1654.3	-4.829	2.829
681.0	-9.435	3.353	0.268E-02	2.279	-1.402	4.439	1660.3	-2.571	2.833
703.3	-10.339	3.362	0.275E-05	2.286	-1.537	4.344	1682.6	-5.560	2.847
719.0	-10.867	3.426	0.278E-04	2.328	-1.586	4.410	1698.3	-4.556	2.857
743.0	-11.145	3.491	0.188E-04	2.374	-1.658	4.462	1722.3	-4.726	2.871
766.5	-11.410	3.522	0.901E-05	2.386	-1.698	4.462	1745.8	-5.045	2.885
803.5	-11.718	3.540	0.332E-05	2.408	-1.744	4.474	1782.8	-5.478	2.905
817.5	-12.373	3.550	0.488E-05	2.415	-1.842	4.411	1796.8	-5.311	2.912
839.0	-12.547	3.603	0.172E-04	2.452	-1.868	4.480	1818.3	-4.765	2.924
863.0	-12.161	3.635	0.912E-05	2.473	-1.810	4.581	1842.3	-5.040	2.936
893.5	-12.461	3.635	0.0	2.473	-1.855	4.544	1872.8	0.0	0.0
934.5	-12.968	3.651	0.267E-05	2.484	-1.932	4.508	1913.8	-5.574	2.971
968.5	-13.068	3.651	0.0	2.484	-1.947	4.496	1947.8	0.0	0.0
991.5	-13.069	3.653	0.593E-06	2.486	-1.947	4.499	1970.8	-6.227	2.996
1006.5	-13.074	3.653	0.456E-05	2.493	-1.947	4.515	1985.8	-5.341	3.003

AVLIN EQUATION NUMBER 3

Y = -.9800253 -2.352807 X - .5127057 X**2 + .2870260 X**3

T-VALUES ARE : 2.1303 0.5375 1.3990
RSQUARE = 0.7646 STD. ERR. OF EST. = .7397851

LOAD INCREMENT # 5 S.D. = 392 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.6	-13.206	3.646	0.413E-01	2.481	-1.967	4.471	1986.4	-1.384	-0.222
11.4	-13.202	3.683	0.234E-04	2.506	-1.967	4.533	1997.2	-4.630	1.057
24.0	-13.179	3.741	0.320E-04	2.547	-1.963	4.635	2009.8	-4.494	1.380
47.5	-13.226	3.736	-0.146E-05	2.543	-1.970	4.621	2033.3	-4.869	1.534
72.5	-13.342	3.771	0.958E-05	2.567	-1.988	4.665	2058.3	-5.019	1.860
96.5	-13.397	3.782	0.313E-05	2.575	-1.996	4.677	2082.3	-5.504	1.985
119.5	-13.446	3.779	-0.891E-06	2.573	-2.003	4.666	2105.3	-5.226	1.978
143.5	-13.499	3.786	0.200E-05	2.577	-2.011	4.671	2129.3	-5.700	2.157
168.5	-13.513	3.818	0.904E-05	2.600	-2.014	4.724	2154.3	-5.044	2.227
192.0	-13.534	3.865	0.137E-04	2.632	-2.032	4.788	2177.8	-4.864	2.283
216.5	-13.587	3.870	0.140E-05	2.636	-2.040	4.790	2202.3	-5.855	2.335
240.0	-13.784	3.886	0.467E-05	2.647	-2.056	4.804	2225.8	-5.331	2.380
264.0	-13.844	3.886	0.0	2.647	-2.063	4.798	2249.8	-5.437	2.381
288.0	-13.894	3.886	0.0	2.647	-2.071	4.792	2273.8	-6.082	2.423
312.0	-13.894	3.886	0.0	2.647	-2.071	4.792	2297.8	-5.314	2.468
336.0	-14.045	3.888	0.569E-06	2.648	-2.094	4.777	2321.8	-6.245	2.526
360.0	-14.105	3.911	0.656E-05	2.664	-2.103	4.808	2345.8	-5.183	2.556
384.0	-14.158	3.919	0.228E-05	2.669	-2.111	4.815	2369.8	-5.642	2.584
408.0	-14.206	3.913	-0.171E-05	2.665	-2.118	4.799	2393.8	-5.952	2.584
432.0	-14.207	3.917	0.114E-05	2.668	-2.118	4.805	2417.8	-5.943	2.635
457.0	-14.250	3.900	-0.466E-05	2.656	-2.125	4.771	2442.8	-6.077	2.635
479.5	-14.300	3.901	0.304E-06	2.657	-2.132	4.767	2465.3	-6.517	2.681
504.0	-14.369	3.943	0.117E-04	2.686	-2.143	4.829	2489.8	-4.930	2.702
528.0	-14.422	3.949	0.171E-05	2.690	-2.150	4.832	2513.8	-5.767	2.723
552.0	-14.520	3.946	-0.857E-06	2.688	-2.165	4.815	2537.8	-5.383	2.722
577.0	-14.562	3.928	-0.493E-05	2.675	-2.172	4.780	2562.8	-5.709	2.741
600.0	-14.618	3.940	0.358E-05	2.684	-2.180	4.793	2585.8	-5.446	2.778
624.5	-14.614	3.931	-0.252E-05	2.677	-2.179	4.779	2610.3	-5.051	2.778
648.5	-14.667	3.939	0.229E-05	2.683	-2.187	4.785	2634.3	-5.641	2.812
671.0	-14.771	3.947	0.244E-05	2.688	-2.203	4.786	2656.8	-5.613	2.827
696.5	-14.824	3.955	0.215E-05	2.694	-2.211	4.793	2682.3	-5.668	2.843
719.5	-14.920	3.945	-0.298E-05	2.687	-2.226	4.764	2705.3	-5.560	2.847
743.5	-14.923	3.952	0.200E-05	2.692	-2.226	4.776	2729.3	-5.699	2.871
768.5	-14.879	3.965	0.384E-05	2.701	-2.219	4.805	2754.3	-5.416	2.886
792.5	-14.927	3.960	-0.171E-05	2.697	-2.227	4.789	2778.3	-5.045	2.885
817.0	-14.979	3.984	0.140E-05	2.701	-2.234	4.791	2802.8	-5.855	2.912
839.0	-14.984	3.975	0.342E-05	2.708	-2.235	4.809	2824.8	-5.466	2.924
864.0	-15.118	4.052	0.211E-04	2.761	-2.255	4.921	2849.8	-4.675	2.937
887.0	-15.172	4.062	0.298E-05	2.768	-2.264	4.931	2872.8	-5.525	2.948
913.0	-15.222	4.061	-0.264E-06	2.767	-2.271	4.924	2898.8	0.0	0.0
935.0	-15.286	4.091	0.966E-05	2.788	-2.281	4.968	2920.8	-5.015	2.971
967.0	-15.421	4.058	-0.729E-05	2.765	-2.301	4.894	2952.8	0.0	0.0
986.0	-15.474	4.066	0.289E-05	2.771	-2.309	4.901	2971.8	-5.540	2.994
1006.5	-15.523	4.063	-0.100E-05	2.769	-2.317	4.890	2992.3	-5.341	3.003
1030.5	-15.569	4.055	-0.229E-05	2.763	-2.324	4.871	3016.3	-2.000	0.0
1054.5	-15.668	4.052	-0.856E-06	2.761	-2.338	4.854	3040.3	0.600	0.700
1081.5	-15.765	4.045	-0.178E-05	2.756	-2.353	4.830	3067.3	0.0	0.0
1108.5	-15.865	4.046	0.254E-06	2.757	-2.368	4.819	3094.3	-6.595	3.045
1128.5	-15.914	4.044	-0.686E-06	2.755	-2.376	4.810	3114.3	0.0	0.0
1154.5	-15.965	4.046	0.528E-06	2.757	-2.383	4.807	3140.3	-6.278	3.062
1177.0	-15.968	4.052	0.183E-05	2.761	-2.384	4.817	3162.8	-5.738	3.071
1201.0	-16.064	4.043	-0.257E-05	2.755	-2.398	4.790	3186.8	0.0	0.0
1226.5	-16.086	4.048	0.134E-05	2.758	-2.399	4.798	3212.3	-5.872	3.089
1249.0	-16.061	4.037	-0.335E-05	2.751	-2.398	4.780	3234.8	0.0	0.0
1273.0	-16.110	4.034	-0.855E-06	2.749	-2.405	4.769	3258.8	0.0	0.0
1297.0	-16.026	4.071	0.106E-04	2.774	-2.393	4.841	3282.8	-4.976	3.113
1321.0	-15.827	4.072	0.286E-06	2.775	-2.363	4.868	3306.8	-6.543	3.121
1345.0	-15.885	4.091	0.543E-05	2.788	-2.371	4.892	3330.8	-5.265	3.129
1393.0	-15.988	4.096	0.857E-06	2.792	-2.387	4.890	3378.8	-6.067	3.144

AVLIN EQUATION NUMBER 4

Y = -.3974371 -1.808702 X -.8720366 X**2 + .2990469 X**3

T-VALUES ARE : 1.9075 1.1548 1.9556

RSQUARE = 0.8939 STD. ERR. OF EST. = .6887091

LOAD INCREMENT # 6 S.D.= 490 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.5	-16.132	4.127	0.563E-01	2.813	-2.409	4.924	3379.3	-1.250	-0.301
7.3	-16.130	4.233	0.108E-03	2.887	-2.408	5.104	3386.1	-3.967	0.863
24.0	-16.098	4.385	0.629E-04	2.992	-2.403	5.366	3402.8	-4.201	1.380
32.0	-15.979	4.455	0.601E-04	3.040	-2.385	5.498	3410.8	-4.221	1.505
48.0	-15.988	4.587	0.572E-04	3.131	-2.387	5.721	3426.8	-4.243	1.681
74.0	-15.929	4.789	0.540E-04	3.272	-2.378	6.073	3452.8	-4.267	1.869
120.0	-15.754	5.068	0.421E-04	3.466	-2.351	6.569	3498.8	-4.375	2.079
144.5	-15.706	5.184	0.330E-04	3.546	-2.344	6.773	3523.3	-4.482	2.160
168.5	-15.648	5.278	0.274E-04	3.612	-2.336	6.941	3547.3	-4.563	2.227
176.8	-15.574	5.335	0.475E-04	3.652	-2.324	7.047	3555.6	-4.323	2.247
192.5	-15.515	5.426	0.406E-04	3.715	-2.315	7.210	3571.3	-4.392	2.284
216.5	-15.485	5.583	0.456E-04	3.825	-2.311	7.481	3595.3	-4.341	2.335
242.0	-15.335	5.805	0.609E-04	3.980	-2.288	7.881	3620.8	-4.215	2.384
265.5	-15.086	6.030	0.668E-04	4.137	-2.251	8.296	3644.3	-4.175	2.424
288.5	-15.042	6.288	0.728E-04	4.304	-2.244	8.710	3667.3	-4.139	2.460
312.5	-14.837	6.478	0.616E-04	4.452	-2.213	9.097	3691.3	-4.211	2.495
336.5	-14.690	6.708	0.672E-04	4.613	-2.191	9.510	3715.3	-4.173	2.527
360.5	-14.683	6.804	0.282E-04	4.661	-2.190	9.677	3739.3	-4.549	2.557
384.5	-14.530	6.908	0.306E-04	4.754	-2.167	9.876	3763.3	-4.514	2.585
410.5	-14.365	6.987	0.215E-04	4.810	-2.142	10.033	3789.3	-4.667	2.613
441.5	-14.312	7.092	0.237E-04	4.884	-2.134	10.220	3820.3	-4.625	2.645
456.5	-14.238	7.149	0.271E-04	4.924	-2.123	10.329	3835.3	-4.567	2.659
480.5	-14.132	7.135	-0.409E-05	4.914	-2.107	10.318	3859.3	-4.930	2.702
504.5	-14.028	7.350	0.631E-04	5.066	-2.091	10.701	3883.3	-4.200	2.703
528.5	-13.836	7.480	0.383E-04	5.158	-2.062	10.950	3907.3	-4.417	2.723
552.5	-13.710	7.644	0.488E-04	5.274	-2.043	11.251	3931.3	-4.313	2.742
576.5	-13.711	7.758	0.308E-04	5.355	-2.043	11.448	3957.3	-4.511	2.762
603.5	-13.377	7.904	0.417E-04	5.459	-1.993	11.744	3982.3	-4.380	2.781
624.5	-13.124	8.121	0.732E-04	5.613	-1.955	12.152	4003.3	-4.136	2.796
648.5	-12.879	8.355	0.694E-04	5.779	-1.918	12.590	4027.3	-4.158	2.812
672.5	-12.545	8.613	0.766E-04	5.963	-1.868	13.081	4051.3	-4.116	2.828
696.0	-12.298	8.844	0.703E-04	6.128	-1.831	13.516	4074.8	-4.153	2.843
720.5	-12.009	9.091	0.721E-04	6.305	-1.788	13.984	4099.3	-4.142	2.858
748.5	-11.792	9.275	0.470E-04	6.436	-1.755	14.333	4127.3	-4.328	2.874
780.0	-11.564	9.436	0.366E-04	6.552	-1.721	14.644	4158.8	-4.437	2.892
816.0	-11.344	9.613	0.354E-04	6.679	-1.688	14.983	4194.8	-4.451	2.912
840.0	-11.152	9.744	0.392E-04	6.773	-1.659	15.237	4218.8	-4.406	2.924
864.0	-10.965	9.883	0.417E-04	6.873	-1.631	15.505	4242.8	-4.380	2.937
888.0	-10.831	10.032	0.447E-04	6.981	-1.611	15.784	4266.8	-4.350	2.948
916.0	-10.603	10.191	0.409E-04	7.095	-1.576	16.092	4294.8	-4.388	2.962
940.0	-10.418	10.337	0.439E-04	7.201	-1.549	16.373	4318.8	-4.358	2.973
960.0	-10.229	10.472	0.488E-04	7.298	-1.520	16.635	4338.8	-4.312	2.982
984.0	-10.062	10.657	0.559E-04	7.432	-1.495	16.984	4362.8	-4.252	2.993

AVLIN EQUATION NUMBER 5

Y = -2.198953 -2.715420 X + 1.107275 X**2 -.1471249 X**3

T-VALUES ARE : 10.3393 4.9358 3.0221

RSQUARE = 0.8884 STD. ERR. OF EST. = .1747804

PLOT 1, 378 UNPLOTTABLE POINTS

GEOTECHNICAL LABORATORIES
DEPARTMENT OF CIVIL ENGINEERING
UNIVERSITY OF MANITOBA

CONSTANT MEAN NORMAL STRESS MULTI-STAGE TRIAXIAL CREEP TEST
MST3 – $\bar{\sigma}m$=280 kPa

LOAD INCREMENT # 1 S.D.= 0 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
2.0	-5.051	-0.124	-0.410E-03	-0.082	-0.743	0.808	2.0	0.0	0.0
22.5	-6.553	-0.122	0.651E-06	-0.081	-0.986	0.986	22.5	-6.187	1.352
33.5	-6.966	-0.105	0.100E-04	-0.070	-1.027	1.009	33.5	-4.998	1.525
46.5	-7.483	-0.084	0.108E-04	-0.056	-1.103	1.038	46.5	-4.976	1.667
70.3	-8.293	-0.072	0.356E-05	-0.047	-1.224	1.115	70.3	-5.448	1.847
95.7	-8.854	-0.058	0.358E-05	-0.038	-1.307	1.161	95.7	-5.449	1.981
122.6	-9.413	-0.047	0.270E-05	-0.031	-1.390	1.211	122.6	-5.569	2.088
142.6	-9.713	-0.046	0.286E-06	-0.031	-1.435	1.246	142.6	-6.544	2.154
163.3	-10.227	-0.029	0.539E-05	-0.019	-1.511	1.281	163.3	-5.266	2.213
187.5	-10.481	-0.023	0.162E-05	-0.015	-1.548	1.303	187.5	-5.792	2.273
210.6	-10.740	-0.013	0.310E-05	-0.008	-1.587	1.316	210.6	-5.509	2.323
219.3	-10.842	-0.011	0.153E-05	-0.007	-1.603	1.326	219.3	-5.814	2.341
234.4	-11.044	-0.008	0.126E-05	-0.005	-1.633	1.345	234.4	-5.888	2.370
259.5	-11.265	0.019	0.699E-05	0.013	-1.666	1.329	259.5	-5.155	2.414
283.4	-11.567	0.022	0.818E-06	0.014	-1.711	1.361	283.4	-6.087	2.452
306.5	-11.963	0.017	-0.141E-05	0.011	-1.770	1.418	306.5	0.0	0.0
332.8	-12.389	0.049	0.819E-05	0.033	-1.833	1.417	332.8	-5.087	2.522
354.1	-12.586	0.045	-0.123E-05	0.030	-1.863	1.447	354.1	0.0	0.0
378.2	-12.735	0.043	-0.542E-06	0.029	-1.885	1.459	378.2	0.0	0.0
402.2	-12.935	0.043	0.0	0.029	-1.915	1.493	402.2	0.0	0.0
427.4	-13.088	0.047	0.104E-05	0.031	-1.938	1.505	427.4	-5.985	2.631
456.2	-13.387	0.046	-0.228E-06	0.031	-1.983	1.543	456.2	0.0	0.0
480.8	-13.588	0.048	0.531E-06	0.032	-2.013	1.565	480.8	-6.275	2.682
507.3	-13.786	0.045	-0.738E-06	0.030	-2.042	1.594	507.3	0.0	0.0
530.9	-13.989	0.049	0.111E-05	0.033	-2.073	1.612	530.9	-5.955	2.725
570.2	-14.392	0.052	0.498E-06	0.035	-2.133	1.657	570.2	-6.303	2.756

LOAD INCREMENT # 2 S.D.= 196 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
7.4	-0.152	0.441	0.397E-03	0.294	-0.023	0.701	7.4	-3.401	0.869
25.3	-0.553	0.505	0.238E-04	0.336	-0.083	0.756	25.3	-4.624	1.403
56.4	-0.948	0.562	0.122E-04	0.374	-0.142	0.800	56.4	-4.913	1.751
72.1	-1.164	0.582	0.834E-05	0.387	-0.174	0.806	72.1	-5.079	1.858
96.0	-1.377	0.598	0.466E-05	0.398	-0.206	0.807	96.0	-5.332	1.982
120.0	-1.594	0.619	0.573E-05	0.412	-0.239	0.814	120.0	-5.242	2.079
143.9	-1.805	0.633	0.384E-05	0.421	-0.271	0.811	143.9	-5.416	2.158
167.7	-2.016	0.647	0.385E-05	0.430	-0.302	0.808	167.7	-5.414	2.225
199.2	-2.234	0.869	0.478E-05	0.446	-0.335	0.818	199.2	-5.321	2.299
221.4	-2.440	0.677	0.237E-05	0.451	-0.366	0.805	221.4	-5.626	2.345
240.0	-2.647	0.686	0.317E-05	0.457	-0.397	0.794	240.0	-5.499	2.380
263.0	-2.944	0.683	-0.854E-06	0.455	-0.442	0.753	263.0	-5.814	2.341
287.8	-3.245	0.684	0.263E-06	0.455	-0.487	0.718	287.8	-6.580	2.459
311.7	-3.446	0.685	0.271E-06	0.456	-0.517	0.695	311.7	-6.568	2.494
337.4	-3.548	0.688	0.767E-06	0.458	-0.533	0.687	337.4	-6.115	2.528
367.0	-3.648	0.688	0.0	0.458	-0.548	0.675	367.0	0.0	0.0
410.0	-3.851	0.691	0.457E-06	0.460	-0.578	0.654	410.0	-6.340	2.613

AYLIN EQUATION NUMBER 1

Y = .2837603E-01 -6.457802 X + 3.249499 X**2 -.6621088 X**3

T-VALUES ARE : 7.1143 4.0088 3.4055

RSQUARE = 0.9760 STD. ERR. OF EST. = .2622861

LOAD INCREMENT # 3 S.D.= 392 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
9.3	-4.319	0.964	0.891E-03	0.643	-0.649	1.044	419.3	-3.161	0.968
23.6	-4.485	1.172	0.974E-04	0.782	-0.674	1.365	433.6	-4.012	1.373
34.5	-4.612	1.269	0.591E-04	0.846	-0.693	1.507	444.5	-4.228	1.538
47.8	-4.734	1.359	0.455E-04	0.907	-0.711	1.641	457.8	-4.342	1.679
71.6	-4.988	1.465	0.299E-04	0.978	-0.747	1.786	481.6	-4.525	1.855
95.3	-5.176	1.538	0.206E-04	1.027	-0.778	1.880	505.3	-4.687	1.979
126.3	-5.351	1.632	0.204E-04	1.090	-0.804	2.013	536.3	-4.690	2.101
149.6	-5.461	1.644	0.340E-05	1.098	-0.821	2.019	559.6	-5.469	2.175
167.4	-5.583	1.671	0.104E-04	1.116	-0.839	2.049	577.4	-4.984	2.224
191.4	-5.717	1.714	0.121E-04	1.145	-0.860	2.104	601.4	-4.917	2.282
215.0	-5.858	1.766	0.145E-04	1.180	-0.881	2.171	625.0	-4.837	2.332
240.8	-5.990	1.806	0.105E-04	1.207	-0.901	2.221	650.8	-4.979	2.382
265.1	-6.112	1.834	0.788E-05	1.226	-0.919	2.252	675.1	-5.104	2.423
294.1	-6.241	1.870	0.819E-05	1.250	-0.939	2.295	704.1	-5.086	2.468
313.6	-6.311	1.895	0.881E-05	1.267	-0.949	2.328	723.6	-5.055	2.496
335.6	-6.528	1.917	0.660E-05	1.281	-0.982	2.337	745.6	-5.180	2.526
359.6	-6.698	1.943	0.743E-05	1.299	-1.008	2.359	769.6	-5.129	2.556
383.6	-6.821	1.971	0.771E-05	1.318	-1.026	2.390	793.6	-5.113	2.584
407.6	-6.948	2.004	0.936E-05	1.340	-1.046	2.428	817.6	-5.029	2.610
431.6	-7.175	2.038	0.964E-05	1.363	-1.080	2.458	841.6	-5.016	2.635
460.9	-7.309	2.081	0.970E-05	1.392	-1.100	2.511	870.9	-5.013	2.664
479.7	-7.435	2.113	0.116E-04	1.414	-1.119	2.549	889.7	-4.935	2.681
503.3	-7.568	2.154	0.118E-04	1.441	-1.139	2.600	913.3	-4.929	2.702
527.6	-7.686	2.178	0.654E-05	1.457	-1.157	2.625	937.6	-5.185	2.722
551.6	-7.815	2.213	0.993E-05	1.481	-1.177	2.667	961.6	-5.003	2.742
575.6	-7.944	2.251	0.105E-04	1.506	-1.196	2.713	985.6	-4.980	2.760
600.4	-8.082	2.298	0.128E-04	1.538	-1.217	2.774	1010.4	-4.892	2.778
634.4	-8.301	2.321	0.468E-05	1.554	-1.250	2.785	1044.4	-5.330	2.802
675.3	-8.085	2.427	0.175E-04	1.626	-1.218	2.987	1085.3	-4.757	2.829
681.2	-8.369	4.163	0.198E-02	2.804	-1.261	5.840	1091.2	-2.703	2.833
695.3	-7.882	4.305	0.688E-04	2.901	-1.187	6.137	1105.3	-4.163	2.842
719.3	-7.752	4.267	-0.106E-04	2.876	-1.167	6.091	1129.3	0.0	0.0
743.8	-8.130	4.364	0.271E-04	2.942	-1.225	6.207	1153.8	-4.567	2.871
767.3	-8.226	4.422	0.169E-04	2.982	-1.239	6.292	1177.3	-4.773	2.885
782.5	-8.340	4.440	0.796E-05	2.994	-1.256	6.307	1192.5	-5.099	2.893
805.5	-8.378	4.487	0.140E-04	3.026	-1.282	6.382	1215.5	-4.853	2.906
819.5	-8.656	4.523	0.173E-04	3.050	-1.304	6.407	1229.5	-4.762	2.914
841.0	-8.732	4.618	0.303E-04	3.116	-1.316	6.557	1251.0	-4.518	2.925
865.0	-8.323	4.732	0.325E-04	3.194	-1.254	6.799	1275.0	-4.488	2.937
895.5	-8.456	4.773	0.927E-05	3.222	-1.274	6.852	1305.5	-5.033	2.952
936.0	-9.097	4.825	0.882E-05	3.258	-1.371	6.860	1346.0	-5.055	2.971
970.0	-9.321	4.855	0.614E-05	3.278	-1.405	6.883	1380.0	-5.212	2.987
993.0	-9.439	4.878	0.674E-05	3.294	-1.423	6.906	1403.0	-5.171	2.997
1006.0	-9.567	4.913	0.187E-04	3.318	-1.443	6.950	1416.0	-4.729	3.003
1030.0	-9.691	4.943	0.843E-05	3.338	-1.461	6.984	1440.0	-5.074	3.013
1053.5	-9.813	4.970	0.804E-05	3.357	-1.480	7.015	1463.5	-5.095	3.023
1078.5	-9.953	5.020	0.138E-04	3.392	-1.501	7.082	1488.5	-4.861	3.033
1102.0	-10.084	5.071	0.149E-04	3.427	-1.523	7.151	1512.0	-4.826	3.042
1125.0	-10.228	5.115	0.129E-04	3.457	-1.543	7.207	1535.0	-4.889	3.051
1149.0	-10.093	5.196	0.234E-04	3.513	-1.523	7.361	1559.0	-4.632	3.060
1174.0	-10.081	5.306	0.303E-04	3.588	-1.521	7.548	1584.0	-4.519	3.070
1197.5	-10.117	5.414	0.317E-04	3.663	-1.526	7.726	1607.5	-4.500	3.078
1222.0	-10.114	5.473	0.166E-04	3.703	-1.526	7.825	1632.0	-4.781	3.087
1245.5	-10.265	5.538	0.190E-04	3.748	-1.549	7.916	1655.5	-4.721	3.095
1269.5	-10.313	5.598	0.172E-04	3.789	-1.556	8.011	1679.5	-4.764	3.104
1293.5	-10.312	5.659	0.175E-04	3.831	-1.556	8.114	1703.5	-4.757	3.112
1317.5	-10.315	5.725	0.192E-04	3.877	-1.556	8.227	1727.5	-4.717	3.120
1341.5	-10.423	5.798	0.209E-04	3.928	-1.573	8.336	1751.5	-4.680	3.128
1365.5	-10.489	5.880	0.237E-04	3.985	-1.583	8.468	1775.5	-4.624	3.135
1389.5	-10.510	5.970	0.257E-04	4.046	-1.586	8.617	1799.5	-4.589	3.143
1413.5	-10.524	6.050	0.232E-04	4.102	-1.588	8.751	1823.5	-4.634	3.150
1437.5	-10.500	6.146	0.275E-04	4.168	-1.584	8.916	1847.5	-4.561	3.158
1462.5	-10.429	6.245	0.275E-04	4.237	-1.574	9.093	1872.5	-4.561	3.165
1484.5	-10.321	6.361	0.365E-04	4.317	-1.557	9.303	1894.5	-4.438	3.172
1508.5	-10.265	6.540	0.520E-04	4.442	-1.549	9.615	1918.5	-4.284	3.179
1532.5	-9.823	6.738	0.574E-04	4.580	-1.481	10.008	1942.5	-4.241	3.185
1556.5	-9.574	6.928	0.549E-04	4.711	-1.444	10.362	1966.5	-4.280	3.192
1581.5	-9.319	7.110	0.506E-04	4.838	-1.405	10.703	1991.5	-4.296	3.199
1604.5	-9.060	7.286	0.536E-04	4.961	-1.356	11.038	2014.5	-4.271	3.205
1629.0	-8.901	7.464	0.507E-04	5.085	-1.342	11.361	2039.0	-4.295	3.212
1653.0	-8.621	7.677	0.621E-04	5.234	-1.299	11.781	2063.0	-4.207	3.218
1675.5	-8.382	7.816	0.431E-04	5.331	-1.263	12.028	2085.5	-4.366	3.224
1700.5	-8.352	7.967	0.424E-04	5.437	-1.258	12.291	2110.5	-4.373	3.231
1723.5	-8.377	8.081	0.288E-04	5.503	-1.262	12.450	2133.5	-4.541	3.236
1747.5	-8.349	8.150	0.281E-04	5.566	-1.258	12.607	2157.5	-4.583	3.242
1772.5	-8.333	8.257	0.298E-04	5.641	-1.255	12.792	2182.5	-4.526	3.249
1797.5	-8.396	8.335	0.221E-04	5.696	-1.265	12.919	2207.5	-4.656	3.255
1821.5	-8.464	8.408	0.213E-04	5.747	-1.274	13.037	2231.5	-4.672	3.260
1843.5	-8.405	8.473	0.207E-04	5.793	-1.266	13.155	2253.5	-4.683	3.266
1848.5	-8.383	8.507	0.484E-04	5.817	-1.263	13.217	2258.5	-4.315	3.267

AYLIN EQUATION NUMBER 2

Y = .1716730E-01 -3.972292 X + .7465824 X**2 + .1651259E-01 X**3

T-VALUES ARE : 6.0530 1.8283 0.2276

RSQUARE = 0.7752 STD. ERR. OF EST. = .3249943

PLOT 1, 120 UNPLOTTABLE POINTS

GEOTECHNICAL LABORATORIES
DEPARTMENT OF CIVIL ENGINEERING
UNIVERSITY OF MANITOBA

CONSTANT MEAN NORMAL STRESS MULTI-STAGE TRIAXIAL CREEP TEST

MST4 – $\bar{\sigma}m$=70 kPa

LOAD INCREMENT # 1 S.D.= 0 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.1	-1.000	0.0	0.0	0.0	-0.146	0.119	0.1	0.0	0.0
6.3	-1.509	0.021	0.225E-04	0.014	-0.220	0.146	6.3	-4.648	0.796
24.3	-2.166	0.035	0.512E-05	0.023	-0.316	0.202	24.3	-5.291	1.385
51.0	-2.836	0.079	0.111E-04	0.053	-0.414	0.209	51.0	-4.956	1.708
75.0	-3.382	0.071	-0.220E-05	0.047	-0.494	0.267	75.0	0.0	0.0
96.0	-3.834	0.075	0.125E-05	0.050	-0.560	0.335	96.0	-5.902	1.982
120.0	-4.267	0.149	0.203E-04	0.099	-0.623	0.267	120.0	-4.692	2.079
144.0	-4.775	0.168	0.521E-05	0.111	-0.698	0.297	144.0	-5.283	2.158
168.5	-5.080	0.178	0.269E-05	0.118	-0.743	0.318	168.5	-5.570	2.227
194.0	-5.490	0.201	0.620E-05	0.134	-0.803	0.328	194.0	-6.208	2.288
220.5	-5.793	0.207	0.149E-05	0.138	-0.847	0.355	220.5	-5.827	2.343
240.0	-6.095	0.211	0.135E-05	0.140	-0.892	0.385	240.0	-5.870	2.380
264.0	-6.398	0.219	0.220E-05	0.145	-0.936	0.408	264.0	-5.858	2.422
288.0	-6.701	0.225	0.165E-05	0.149	-0.981	0.435	288.0	-5.783	2.459
311.0	-6.901	0.224	-0.285E-06	0.148	-1.010	0.460	311.0	0.0	0.0
336.0	-7.202	0.228	0.105E-05	0.151	-1.055	0.490	336.0	-5.978	2.526
362.0	-7.502	0.226	-0.507E-06	0.150	-1.099	0.529	362.0	0.0	0.0
386.0	-7.702	0.226	0.0	0.150	-1.128	0.553	386.0	0.0	0.0
408.5	-7.902	0.226	0.0	0.150	-1.158	0.577	408.5	0.0	0.0
432.5	-8.101	0.224	-0.547E-06	0.149	-1.187	0.605	432.5	0.0	0.0
456.5	-8.301	0.225	0.274E-06	0.149	-1.216	0.627	456.5	-6.563	2.659
479.5	-8.501	0.225	0.0	0.149	-1.246	0.651	479.5	0.0	0.0
504.5	-8.701	0.224	-0.263E-06	0.148	-1.275	0.677	504.5	0.0	0.0
533.0	-8.855	0.233	0.208E-05	0.155	-1.298	0.681	533.0	-5.682	2.727
555.5	-9.055	0.234	0.294E-06	0.155	-1.328	0.703	555.5	-6.531	2.745
576.5	-9.256	0.237	0.941E-06	0.157	-1.357	0.723	576.5	-6.026	2.761
600.5	-9.456	0.237	0.0	0.157	-1.387	0.747	600.5	0.0	0.0
624.5	-9.606	0.237	0.0	0.157	-1.409	0.765	624.5	0.0	0.0
647.5	-9.856	0.236	-0.288E-06	0.157	-1.446	0.797	647.5	0.0	0.0
672.5	-10.007	0.238	0.528E-06	0.158	-1.468	0.812	672.5	-6.278	2.828
697.5	-10.206	0.237	-0.263E-06	0.157	-1.498	0.837	697.5	0.0	0.0
723.5	-10.406	0.237	0.0	0.157	-1.527	0.862	723.5	0.0	0.0
744.5	-10.506	0.237	0.0	0.157	-1.542	0.874	744.5	0.0	0.0
768.5	-10.705	0.233	-0.110E-05	0.155	-1.571	0.904	768.5	0.0	0.0
792.5	-10.855	0.233	0.0	0.155	-1.594	0.922	792.5	0.0	0.0
815.5	-11.004	0.232	-0.286E-06	0.154	-1.616	0.942	815.5	0.0	0.0
840.5	-11.105	0.233	0.263E-06	0.155	-1.631	0.952	840.5	-6.581	2.925
866.0	-11.305	0.233	0.0	0.155	-1.660	0.977	866.0	0.0	0.0
890.0	-11.405	0.233	0.0	0.155	-1.675	0.989	890.0	0.0	0.0
918.5	-11.606	0.235	0.463E-06	0.156	-1.705	1.010	918.5	-6.335	2.963
936.5	-11.756	0.235	0.0	0.156	-1.727	1.028	936.5	0.0	0.0
960.5	-11.906	0.237	0.550E-06	0.157	-1.749	1.043	960.5	-6.260	2.982

LOAD INCREMENT # 2 S.D.= 49 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.1	-0.227	-0.030	-0.198E-02	-0.020	-0.034	0.076	0.1	0.0	0.0
10.0	-0.215	0.167	0.132E-03	0.111	-0.032	0.246	10.0	-3.878	1.000
23.5	-0.227	0.194	0.132E-04	0.129	-0.034	0.289	23.5	-4.879	1.371
47.5	-0.287	0.217	0.632E-05	0.144	-0.043	0.319	47.5	-5.199	1.677
80.5	-0.443	0.230	0.260E-05	0.153	-0.066	0.321	80.5	-5.586	1.906
97.0	-0.446	0.237	0.280E-05	0.157	-0.066	0.332	97.0	-5.553	1.987
119.5	-0.549	0.244	0.206E-05	0.162	-0.081	0.330	119.5	-5.687	2.077
143.5	-0.654	0.254	0.275E-05	0.169	-0.097	0.334	143.5	-5.561	2.157
167.5	-0.706	0.259	0.138E-05	0.172	-0.105	0.336	167.5	-5.861	2.224
191.0	-0.807	0.261	0.562E-06	0.173	-0.120	0.327	191.0	-6.251	2.281
215.5	-0.858	0.264	0.807E-06	0.175	-0.127	0.325	215.5	-6.093	2.333
249.0	-1.011	0.270	0.116E-05	0.179	-0.150	0.317	249.0	-5.927	2.396
266.0	-1.065	0.278	0.311E-05	0.185	-0.158	0.323	266.0	-5.508	2.425
287.5	-1.263	0.275	-0.919E-06	0.183	-0.187	0.294	287.5	-5.783	2.459
311.5	-1.269	0.288	0.357E-05	0.191	-0.188	0.314	311.5	-5.447	2.493
335.5	-1.372	0.294	0.165E-05	0.195	-0.204	0.312	335.5	-5.782	2.526
359.5	-1.475	0.300	0.193E-05	0.200	-0.219	0.310	359.5	-5.715	2.556
383.5	-1.529	0.309	0.247E-05	0.206	-0.227	0.318	383.5	-5.607	2.584
417.5	-1.585	0.323	0.272E-05	0.215	-0.235	0.334	417.5	-5.566	2.621
434.5	-1.685	0.323	0.0	0.215	-0.250	0.322	434.5	0.0	0.0
455.5	-1.783	0.319	-0.126E-05	0.212	-0.265	0.304	455.5	-6.563	2.659
479.5	-1.891	0.337	0.495E-05	0.224	-0.281	0.320	479.5	-5.305	2.681
503.5	-2.002	0.360	0.633E-05	0.239	-0.297	0.344	503.5	-5.199	2.702
527.5	-2.153	0.363	0.829E-06	0.241	-0.320	0.330	527.5	-6.081	2.722
551.5	-2.207	0.373	0.275E-05	0.248	-0.328	0.340	551.5	-5.561	2.742
581.5	-2.307	0.373	0.0	0.248	-0.343	0.326	581.5	-6.026	2.761
606.0	-2.400	0.357	-0.431E-05	0.237	-0.356	0.290	606.0	0.0	0.0
623.5	-2.460	0.380	0.868E-05	0.253	-0.385	0.320	623.5	-5.082	2.795
647.5	-2.514	0.387	0.192E-05	0.257	-0.373	0.325	647.5	-5.716	2.811
671.5	-2.620	0.401	0.386E-05	0.266	-0.388	0.335	671.5	-5.414	2.827
695.0	-2.619	0.400	-0.282E-06	0.266	-0.389	0.333	695.0	0.0	0.0
719.5	-2.725	0.413	0.351E-05	0.274	-0.405	0.342	719.5	-5.455	2.857
751.5	-2.880	0.424	0.227E-05	0.282	-0.428	0.340	751.5	-5.644	2.876
772.5	-2.980	0.423	-0.313E-06	0.281	-0.443	0.327	772.5	0.0	0.0
791.5	-3.033	0.430	0.278E-05	0.286	-0.451	0.333	791.5	-5.556	2.898
815.5	-3.134	0.432	0.550E-06	0.288	-0.466	0.324	815.5	-6.259	2.911

AYLIN EQUATION NUMBER 1

Y = .1631737E-02 -5.200793 X = 1.331822 X**2 -.7029428E-01 X**3

T-VALUES ARE : 7.4609 2.2639 0.5575

RSQUARE = 0.9790 STD ERR. OF EST. = .3055937

LOAD INCREMENT # 3 S.D.= 86 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.1	-3.317	0.596	0.387E-01	0.397	-0.493	0.569	815.6	-1.402	-1.000
10.0	-3.283	0.742	0.983E-04	0.494	-0.488	0.811	825.5	-4.008	1.000
24.0	-3.247	0.773	0.147E-04	0.514	-0.482	0.866	839.5	-4.834	1.380
47.5	-3.274	0.833	0.172E-04	0.555	-0.486	0.962	863.0	-4.765	1.677
72.0	-3.289	0.867	0.918E-05	0.577	-0.489	1.015	887.5	-5.037	1.857
102.5	-3.404	0.901	0.739E-05	0.600	-0.506	1.056	918.0	-5.131	2.011
125.0	-3.414	0.923	0.848E-05	0.614	-0.507	1.081	940.5	-5.188	2.097
144.0	-3.459	0.935	0.418E-05	0.622	-0.515	1.103	959.5	-5.378	2.158
168.0	-3.479	0.956	0.808E-05	0.637	-0.517	1.138	983.5	-5.216	2.225
192.0	-3.486	0.972	0.442E-05	0.648	-0.518	1.163	1007.5	-5.354	2.283
216.0	-3.444	0.980	0.497E-05	0.653	-0.512	1.197	1031.5	-5.304	2.334
240.0	-3.501	1.006	0.442E-05	0.670	-0.520	1.217	1055.5	-5.354	2.380
273.0	-3.461	1.028	0.442E-05	0.685	-0.514	1.257	1088.5	-5.354	2.436
293.0	-3.471	1.050	0.730E-05	0.699	-0.516	1.292	1108.5	-5.137	2.467
314.0	-3.525	1.058	0.253E-05	0.705	-0.524	1.298	1129.5	-5.597	2.497
338.0	-3.532	1.074	0.470E-05	0.716	-0.525	1.325	1153.5	-5.328	2.529
362.0	-3.541	1.093	0.526E-05	0.728	-0.526	1.355	1177.5	-5.279	2.559
385.5	-3.599	1.113	0.564E-05	0.742	-0.535	1.380	1201.0	-5.248	2.586
410.0	-3.658	1.132	0.515E-05	0.754	-0.544	1.404	1225.5	-5.288	2.613
441.5	-3.719	1.157	0.527E-05	0.771	-0.553	1.437	1257.0	-5.278	2.645
464.5	-3.825	1.171	0.405E-05	0.780	-0.568	1.447	1280.0	-5.393	2.667
482.0	-3.828	1.177	0.227E-05	0.784	-0.569	1.456	1297.5	-5.644	2.883
506.0	-3.936	1.196	0.526E-05	0.797	-0.585	1.474	1321.5	-5.279	2.704
530.0	-3.991	1.206	0.304E-05	0.804	-0.593	1.485	1345.5	-5.517	2.724
554.0	-4.048	1.220	0.388E-05	0.813	-0.602	1.501	1369.5	-5.412	2.744
578.0	-4.052	1.231	0.304E-05	0.821	-0.602	1.519	1393.5	-5.517	2.762
610.0	-4.076	1.284	0.110E-04	0.856	-0.606	1.602	1425.5	-4.958	2.785
629.5	-4.065	1.260	-0.818E-05	0.840	-0.604	1.564	1445.0	-5.062	2.795
650.0	-4.170	1.270	0.324E-05	0.847	-0.620	1.568	1465.5	-5.489	2.813
674.0	-4.177	1.286	0.443E-05	0.857	-0.621	1.593	1489.5	-5.354	2.829
698.0	-4.184	1.302	0.443E-05	0.868	-0.622	1.618	1513.5	-5.353	2.844
722.0	-4.370	1.316	0.388E-05	0.877	-0.650	1.618	1537.5	-5.411	2.859
746.0	-4.396	1.328	0.380E-05	0.886	-0.654	1.636	1561.5	-5.444	2.873
774.0	-4.405	1.347	0.451E-05	0.898	-0.655	1.666	1589.5	-5.346	2.889
803.5	-4.512	1.363	0.361E-05	0.909	-0.671	1.679	1619.0	-5.443	2.905
818.0	-4.615	1.370	0.321E-05	0.914	-0.686	1.678	1633.5	-5.494	2.913
842.0	-4.621	1.383	0.360E-05	0.922	-0.687	1.698	1657.5	-5.444	2.925
866.0	-4.706	1.395	0.333E-05	0.930	-0.700	1.708	1681.5	-5.478	2.938
890.0	-4.753	1.411	0.444E-05	0.941	-0.707	1.728	1705.5	-5.353	2.949
914.0	-4.792	1.430	0.526E-05	0.954	-0.713	1.754	1729.5	-5.279	2.961
939.0	-4.748	1.445	0.399E-05	0.964	-0.706	1.784	1754.5	-5.399	2.973
966.5	-4.955	1.460	0.387E-05	0.974	-0.737	1.785	1782.0	-5.412	2.985
992.5	-5.062	1.476	0.409E-05	0.985	-0.753	1.798	1808.0	-5.388	2.997
1018.5	-5.129	1.514	0.973E-05	1.010	-0.763	1.852	1834.0	-5.012	3.008
1036.5	-5.192	1.542	0.104E-04	1.028	-0.772	1.890	1852.0	-4.985	3.016
1062.5	-5.284	1.524	-0.461E-05	1.017	-0.786	1.849	1878.0	0.0	0.0
1090.0	-5.290	1.538	0.339E-05	1.026	-0.787	1.871	1905.5	-5.470	3.037
1115.0	-5.415	1.593	0.149E-04	1.063	-0.806	1.947	1930.5	-4.827	3.047
1138.0	-5.503	1.566	-0.810E-05	1.045	-0.819	1.891	1953.5	0.0	0.0
1162.0	-5.610	1.583	0.472E-05	1.056	-0.835	1.905	1977.5	-5.326	3.065
1202.0	-5.722	1.608	0.433E-05	1.073	-0.852	1.934	2017.5	-5.364	3.080
1226.0	-5.727	1.621	0.360E-05	1.082	-0.852	1.955	2041.5	-5.443	3.088
1250.0	-5.833	1.633	0.333E-05	1.090	-0.868	1.961	2065.5	-5.477	3.097
1281.0	-5.918	1.645	0.258E-05	1.098	-0.881	1.971	2096.5	-5.589	3.108
1301.0	-5.950	1.671	0.866E-05	1.115	-0.886	2.009	2116.5	-5.062	3.114
1322.0	-6.048	1.666	-0.158E-05	1.112	-0.900	1.989	2137.5	0.0	0.0
1347.0	-6.153	1.678	0.320E-05	1.120	-0.916	1.996	2162.5	-5.495	3.129
1370.0	-6.213	1.701	0.668E-05	1.135	-0.925	2.026	2185.5	-5.177	3.137
1394.0	-6.266	1.708	0.195E-05	1.140	-0.933	2.031	2209.5	-5.711	3.144
1418.0	-6.372	1.721	0.361E-05	1.149	-0.949	2.039	2233.5	-5.443	3.152
1450.0	-6.379	1.736	0.333E-05	1.159	-0.950	2.064	2265.5	-5.477	3.161
1470.0	-6.385	1.750	0.466E-05	1.169	-0.951	2.087	2285.5	-5.332	3.167
1490.0	-6.490	1.760	0.334E-05	1.175	-0.966	2.090	2305.5	-5.476	3.173
1514.0	-6.596	1.775	0.418E-05	1.185	-0.982	2.102	2329.5	-5.380	3.180
1538.0	-6.655	1.794	0.528E-05	1.198	-0.991	2.125	2353.5	-5.278	3.187
1568.0	-6.718	1.824	0.715E-05	1.218	-1.001	2.167	2381.5	-5.146	3.195
1568.0	-6.817	1.821	-0.913E-06	1.216	-1.015	2.150	2403.5	0.0	0.0
1619.0	-6.923	1.835	0.301E-05	1.225	-1.031	2.160	2434.5	-5.521	3.209
1639.5	-6.931	1.852	0.563E-05	1.237	-1.032	2.187	2455.0	-5.257	3.215
1660.0	-7.033	1.856	0.162E-05	1.240	-1.048	2.182	2475.5	-5.789	3.220
1684.0	-7.039	1.870	0.389E-05	1.249	-1.049	2.204	2499.5	-5.410	3.228
1708.0	-7.128	1.856	0.239E-04	1.307	-1.062	2.334	2523.5	-4.621	3.232
1732.0	-7.152	1.898	-0.161E-04	1.268	-1.066	2.236	2547.5	0.0	0.0
1756.0	-7.258	1.913	0.417E-05	1.278	-1.082	2.248	2571.5	-5.380	3.245
1781.0	-7.264	1.926	0.347E-05	1.287	-1.082	2.268	2596.5	-5.459	3.251
1807.0	-7.360	1.962	0.924E-05	1.311	-1.097	2.315	2622.5	-5.034	3.257
1828.0	-7.427	1.954	-0.254E-05	1.306	-1.107	2.294	2643.5	0.0	0.0
1852.0	-7.481	1.964	0.278E-05	1.312	-1.115	2.304	2667.5	-5.556	3.268

AVLIN EQUATION NUMBER 2

Y = -.4577818 -1.331870 X -1.082401 X**2 + .3274903 X**3

T-VALUES ARE : 6.8961 6.7644 9.4493

RSQUARE = 0.9384 STD. ERR. OF EST. = .3780749

LOAD INCREMENT # 4 S.D.= 147 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.1	-7.779	1.859	0.131E+00	1.309	-1.160	2.259	2667.6	-0.883	-1.000
7.5	-6.696	2.442	0.440E-03	1.634	-0.997	3.188	2675.0	-3.357	0.875
23.0	-6.558	2.581	0.605E-04	1.728	-0.977	3.436	2690.5	-4.218	1.362
47.0	-6.374	2.727	0.411E-04	1.827	-0.948	3.700	2714.5	-4.386	1.672
71.0	-6.282	2.857	0.366E-04	1.915	-0.935	3.926	2738.5	-4.436	1.851
103.0	-6.135	2.976	0.252E-04	1.995	-0.913	4.142	2770.5	-4.599	2.013
121.0	-6.086	3.043	0.254E-04	2.041	-0.903	4.262	2788.5	-4.585	2.083
143.0	-6.053	3.127	0.257E-04	2.098	-0.901	4.402	2810.5	-4.590	2.155
167.0	-5.887	3.202	0.213E-04	2.149	-0.876	4.548	2834.5	-4.671	2.223
191.0	-5.772	3.282	0.224E-04	2.203	-0.859	4.694	2858.5	-4.649	2.281
215.0	-5.753	3.349	0.191E-04	2.248	-0.856	4.808	2882.5	-4.719	2.332
239.0	-5.646	3.446	0.275E-04	2.314	-0.840	4.983	2906.5	-4.560	2.378
264.5	-5.586	3.534	0.233E-04	2.374	-0.831	5.136	2932.0	-4.633	2.422
290.5	-5.532	3.638	0.273E-04	2.445	-0.823	5.316	2958.0	-4.565	2.463
311.0	-5.506	3.690	0.175E-04	2.481	-0.819	5.407	2978.5	-4.758	2.493
335.0	-5.491	3.768	0.220E-04	2.533	-0.817	5.538	3002.5	-4.658	2.525
359.0	-5.375	3.844	0.217E-04	2.585	-0.800	5.680	3026.5	-4.664	2.555
383.0	-5.359	3.920	0.214E-04	2.637	-0.797	5.807	3050.5	-4.669	2.583
407.0	-5.295	4.000	0.228E-04	2.691	-0.788	5.949	3074.5	-4.641	2.610
432.0	-5.124	4.065	0.176E-04	2.735	-0.762	6.078	3099.5	-4.754	2.635
461.0	-5.065	4.157	0.217E-04	2.798	-0.754	6.240	3128.5	-4.663	2.664
479.0	-5.037	4.207	0.188E-04	2.832	-0.749	6.326	3146.5	-4.725	2.680
503.0	-5.020	4.279	0.206E-04	2.882	-0.747	6.449	3170.5	-4.686	2.702
527.0	-4.752	4.351	0.206E-04	2.931	-0.707	6.603	3194.5	-4.685	2.722
551.0	-4.686	4.427	0.215E-04	2.983	-0.697	6.738	3218.5	-4.668	2.741
575.0	-4.535	4.536	0.311E-04	3.058	-0.674	6.939	3242.5	-4.507	2.760
601.0	-4.514	4.600	0.167E-04	3.101	-0.671	7.048	3268.5	-4.777	2.779
624.0	-4.448	4.675	0.225E-04	3.153	-0.661	7.183	3291.5	-4.649	2.795
647.0	-4.330	4.747	0.216E-04	3.202	-0.644	7.319	3314.5	-4.666	2.811
671.0	-4.364	4.824	0.218E-04	3.255	-0.649	7.443	3338.5	-4.661	2.827
695.0	-4.390	4.881	0.164E-04	3.294	-0.653	7.536	3362.5	-4.784	2.842
719.0	-4.121	4.949	0.193E-04	3.341	-0.613	7.683	3386.5	-4.714	2.857
743.0	-4.055	5.025	0.219E-04	3.393	-0.603	7.819	3410.5	-4.660	2.871
769.0	-4.081	5.084	0.155E-04	3.433	-0.607	7.914	3436.5	-4.810	2.886
793.0	-4.107	5.141	0.185E-04	3.473	-0.611	8.008	3460.5	-4.783	2.899
815.0	-4.033	5.200	0.183E-04	3.513	-0.600	8.116	3482.5	-4.738	2.911
839.0	-4.010	5.261	0.173E-04	3.555	-0.596	8.221	3506.5	-4.761	2.924
863.0	-3.939	5.325	0.185E-04	3.599	-0.586	8.338	3530.5	-4.733	2.936
887.0	-3.817	5.386	0.174E-04	3.641	-0.567	8.455	3554.5	-4.760	2.948
911.0	-3.746	5.451	0.188E-04	3.686	-0.557	8.574	3578.5	-4.726	2.960
936.0	-3.678	5.522	0.194E-04	3.734	-0.547	8.701	3603.5	-4.712	2.971
960.0	-3.609	5.591	0.200E-04	3.782	-0.536	8.827	3627.5	-4.700	2.982
983.0	-3.538	5.656	0.193E-04	3.827	-0.526	8.944	3650.5	-4.714	2.993
1007.0	-3.465	5.717	0.177E-04	3.869	-0.515	9.057	3674.5	-4.752	3.003
1031.0	-3.393	5.779	0.177E-04	3.912	-0.504	9.170	3698.5	-4.752	3.013
1055.0	-3.420	5.840	0.177E-04	3.954	-0.508	9.271	3722.5	-4.752	3.023
1079.0	-3.395	5.894	0.154E-04	3.991	-0.504	9.365	3746.5	-4.812	3.033
1104.0	-3.371	5.953	0.165E-04	4.032	-0.501	9.468	3771.5	-4.784	3.043
1132.0	-3.302	6.021	0.167E-04	4.079	-0.490	9.591	3799.5	-4.778	3.054
1151.0	-3.220	6.062	0.152E-04	4.108	-0.478	9.672	3818.5	-4.819	3.061
1175.0	-3.146	6.119	0.163E-04	4.147	-0.467	9.776	3842.5	-4.788	3.070
1199.0	-3.220	6.174	0.157E-04	4.185	-0.478	9.860	3866.5	-4.803	3.079
1223.0	-3.194	6.227	0.155E-04	4.222	-0.475	9.954	3890.5	-4.811	3.087
1247.0	-3.119	6.283	0.160E-04	4.260	-0.463	10.057	3914.5	-4.795	3.096
1272.0	-3.043	6.336	0.149E-04	4.298	-0.452	10.158	3939.5	-4.828	3.104
1296.0	-3.165	6.386	0.143E-04	4.332	-0.470	10.227	3963.5	-4.844	3.113
1319.0	-3.138	6.437	0.153E-04	4.367	-0.466	10.316	3986.5	-4.817	3.120
1343.0	-2.980	6.486	0.143E-04	4.401	-0.440	10.422	4010.5	-4.843	3.128
1367.0	-2.834	6.540	0.155E-04	4.439	-0.421	10.529	4034.5	-4.810	3.136
1391.0	-2.809	6.595	0.161E-04	4.477	-0.417	10.626	4058.5	-4.794	3.143
1415.0	-2.832	6.645	0.144E-04	4.512	-0.421	10.708	4082.5	-4.843	3.151
1440.0	-2.850	6.687	0.116E-04	4.541	-0.423	10.777	4107.5	-4.936	3.158
1468.0	-2.823	6.736	0.123E-04	4.575	-0.419	10.864	4135.5	-4.910	3.167
1487.0	-2.835	6.766	0.105E-04	4.595	-0.421	10.912	4154.5	-4.978	3.172
1512.0	-2.736	6.812	0.130E-04	4.628	-0.406	11.003	4179.5	-4.887	3.180
1535.0	-2.676	6.856	0.135E-04	4.659	-0.397	11.087	4202.5	-4.870	3.186
1559.0	-2.598	6.904	0.138E-04	4.692	-0.386	11.177	4226.5	-4.860	3.193
1588.0	-2.542	6.958	0.129E-04	4.728	-0.377	11.275	4255.5	-4.891	3.201
1608.5	-2.535	6.987	0.101E-04	4.750	-0.376	11.327	4276.0	-4.995	3.208
1633.0	-2.603	7.026	0.110E-04	4.777	-0.386	11.385	4300.5	-4.959	3.213
1655.0	-2.616	7.057	0.974E-05	4.798	-0.389	11.436	4322.5	-5.011	3.219
1679.0	-2.680	7.087	0.864E-05	4.819	-0.398	11.479	4346.5	-5.063	3.225
1703.0	-2.586	7.123	0.107E-04	4.844	-0.386	11.552	4370.5	-4.972	3.231
1727.0	-2.532	7.158	0.101E-04	4.869	-0.376	11.619	4394.5	-4.996	3.237
1751.0	-2.529	7.196	0.110E-04	4.895	-0.375	11.683	4418.5	-4.961	3.243
1777.0	-2.544	7.230	0.905E-05	4.916	-0.378	11.739	4444.5	-5.043	3.250
1806.0	-2.377	7.303	0.165E-04	4.970	-0.353	11.885	4475.5	-4.782	3.257

AVLIN EQUATION NUMBER 3

Y = -2.699370 -1.446239 X + .3647089 X**2 -.3903356E-01 X**3

T-VALUES ARE : 30.8075 6.8641 3.2091

RSQUARE = 0.9661 STD. ERR. OF EST. = .9200639E-01

PLOT 1. 412 UNPLOTTABLE POINTS

GEOTECHNICAL LABORATORIES
DEPARTMENT OF CIVIL ENGINEERING
UNIVERSITY OF MANITOBA

CONSTANT MEAN NORMAL STRESS MULTI-STAGE TRIAXIAL CREEP TEST
MST5 – $\bar{\sigma}_m$=420 kPa

LOAD INCREMENT # 1 S.D.= 0 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.1	2.204	-0.030	-0.198E-02	-0.020	0.318	0.212	0.1	0.0	0.0
8.0	-4.246	-0.083	-0.525E-04	-0.061	-0.617	0.654	8.0	0.0	0.0
23.0	-5.742	-0.088	-0.216E-05	-0.065	-0.835	0.840	23.0	0.0	0.0
48.0	-7.241	-0.100	-0.534E-06	-0.066	-1.054	1.022	48.0	0.0	0.0
74.0	-7.908	-0.015	0.215E-04	-0.010	-1.152	0.965	74.0	-4.668	1.869
98.0	-8.344	0.030	0.124E-04	0.020	-1.216	0.944	98.0	-4.906	1.991
119.5	-8.727	0.071	0.127E-04	0.047	-1.272	0.923	119.5	-4.897	2.077
143.5	-9.099	0.100	0.785E-05	0.066	-1.327	0.922	143.5	-5.105	2.157
167.5	-9.467	0.122	0.623E-05	0.081	-1.381	0.929	167.5	-5.206	2.224
190.5	-9.721	0.127	0.141E-05	0.084	-1.418	0.952	190.5	-5.850	2.280
215.5	-10.025	0.132	0.130E-05	0.087	-1.463	0.980	215.5	-5.886	2.333
244.0	-10.340	0.151	0.433E-05	0.100	-1.509	0.988	244.0	-5.364	2.387
266.5	-10.649	0.161	0.318E-05	0.107	-1.554	1.007	266.5	-5.498	2.426
287.5	-10.853	0.166	0.155E-05	0.110	-1.584	1.024	287.5	-5.810	2.459
311.5	-11.208	0.173	0.189E-05	0.115	-1.637	1.055	311.5	-5.722	2.493
335.5	-11.461	0.177	0.108E-05	0.117	-1.674	1.080	335.5	-5.966	2.526
358.5	-11.663	0.179	0.566E-06	0.119	-1.703	1.101	358.5	-6.247	2.554
383.5	-11.912	0.178	-0.258E-06	0.118	-1.740	1.132	383.5	0.0	0.0
408.5	-12.064	0.180	0.518E-06	0.119	-1.763	1.147	408.5	-6.286	2.811
434.5	-12.350	0.176	-0.100E-05	0.117	-1.806	1.189	434.5	0.0	0.0
455.5	-12.562	0.178	0.622E-06	0.118	-1.836	1.210	455.5	-6.206	2.858
479.5	-12.772	0.191	0.352E-05	0.126	-1.867	1.215	479.5	-5.454	2.681
503.5	-12.969	0.187	-0.108E-05	0.124	-1.896	1.245	503.5	0.0	0.0
526.5	-13.117	0.184	-0.848E-06	0.122	-1.918	1.268	526.5	0.0	0.0
551.5	-13.364	0.180	-0.104E-05	0.119	-1.954	1.304	551.5	0.0	0.0
577.0	-13.514	0.181	0.257E-06	0.120	-1.977	1.320	577.0	-6.589	2.761
601.0	-13.664	0.181	0.0	0.120	-1.999	1.338	601.0	0.0	0.0
629.5	-13.865	0.182	0.226E-06	0.120	-2.028	1.361	629.5	-6.646	2.799
647.5	-13.968	0.185	0.108E-05	0.122	-2.044	1.369	647.5	-5.965	2.811
671.5	-14.167	0.184	-0.271E-06	0.122	-2.073	1.394	671.5	0.0	0.0
695.5	-14.263	0.179	-0.136E-05	0.119	-2.087	1.414	695.5	0.0	0.0
719.5	-14.460	0.178	-0.813E-06	0.117	-2.116	1.443	719.5	0.0	0.0
752.5	-14.659	0.174	-0.394E-06	0.115	-2.146	1.470	752.5	0.0	0.0
768.0	-14.756	0.170	-0.157E-05	0.113	-2.160	1.488	769.0	0.0	0.0
791.5	-14.856	0.170	0.0	0.113	-2.175	1.500	791.5	0.0	0.0
815.5	-14.966	0.170	0.0	0.113	-2.190	1.512	815.5	0.0	0.0
839.5	-15.053	0.167	-0.813E-06	0.111	-2.204	1.528	839.5	0.0	0.0
863.0	-15.153	0.166	-0.274E-06	0.110	-2.219	1.542	863.0	0.0	0.0
888.0	-15.300	0.162	-0.104E-05	0.107	-2.241	1.586	888.0	0.0	0.0
921.5	-15.454	0.168	0.116E-05	0.111	-2.264	1.575	921.5	-5.934	2.964
938.5	-15.546	0.159	-0.382E-05	0.105	-2.277	1.602	938.5	0.0	0.0
960.0	-15.640	0.151	-0.242E-05	0.100	-2.291	1.627	960.0	0.0	0.0
984.0	-15.739	0.150	-0.268E-06	0.099	-2.306	1.640	984.0	0.0	0.0
1008.0	-15.832	0.141	-0.244E-05	0.093	-2.320	1.666	1008.0	0.0	0.0
1032.0	-15.934	0.143	0.539E-06	0.094	-2.335	1.675	1032.0	-6.268	3.014
1056.0	-16.034	0.143	0.0	0.094	-2.349	1.687	1056.0	0.0	0.0
1090.0	-16.134	0.143	0.0	0.094	-2.364	1.699	1090.0	0.0	0.0
1107.0	-16.234	0.143	0.0	0.094	-2.379	1.711	1107.0	0.0	0.0
1128.0	-16.334	0.143	0.0	0.094	-2.394	1.723	1128.0	0.0	0.0
1152.0	-16.434	0.143	0.0	0.094	-2.408	1.735	1152.0	0.0	0.0

LOAD INCREMENT # 2 S.D.= 196 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
8.0	-0.858	0.323	0.271E-03	0.214	-0.127	0.420	8.0	-3.568	0.903
24.0	-1.133	0.418	0.395E-04	0.277	-0.168	0.541	24.0	-4.404	1.380
48.0	-1.420	0.463	0.125E-04	0.307	-0.211	0.680	48.0	-4.904	1.681
72.0	-1.591	0.490	0.732E-05	0.325	-0.236	0.802	72.0	-5.135	1.857
102.0	-1.725	0.533	0.956E-05	0.353	-0.256	0.656	102.0	-5.020	2.009
126.5	-1.838	0.550	0.452E-05	0.364	-0.273	0.669	126.5	-5.345	2.102
144.0	-1.833	0.543	-0.260E-05	0.360	-0.272	0.659	144.0	-5.106	2.157
168.0	-1.949	0.563	0.543E-05	0.373	-0.290	0.677	168.0	-5.265	2.225
192.0	-2.084	0.582	0.543E-05	0.386	-0.307	0.694	192.0	-5.265	2.283
215.5	-2.078	0.599	0.472E-05	0.397	-0.309	0.720	215.5	-5.326	2.333
240.0	-2.183	0.606	0.186E-05	0.401	-0.324	0.718	240.0	-5.730	2.380
272.0	-2.248	0.624	0.387E-05	0.414	-0.334	0.741	272.0	-5.412	2.435
293.0	-2.254	0.632	0.248E-05	0.419	-0.335	0.753	293.0	-5.606	2.467
312.0	-2.303	0.631	-0.340E-06	0.418	-0.342	0.745	312.0	-5.722	2.493
336.0	-2.409	0.638	0.190E-05	0.423	-0.358	0.744	336.0	-5.721	2.526
360.0	-2.417	0.649	0.298E-05	0.430	-0.359	0.760	360.0	-5.525	2.556
384.5	-2.425	0.659	0.268E-05	0.437	-0.361	0.775	384.5	-5.575	2.585
409.0	-2.480	0.665	0.160E-05	0.441	-0.369	0.778	409.0	-5.796	2.612
439.5	-2.535	0.671	0.128E-05	0.444	-0.377	0.781	439.5	-5.892	2.643
462.0	-2.540	0.677	0.203E-05	0.449	-0.378	0.791	462.0	-5.693	2.665
481.0	-2.593	0.680	0.103E-05	0.451	-0.385	0.790	481.0	-5.987	2.682
505.0	-2.653	0.694	0.380E-05	0.460	-0.395	0.805	505.0	-5.420	2.703
529.0	-2.658	0.700	0.163E-05	0.464	-0.395	0.814	529.0	-5.788	2.723
553.0	-2.868	0.713	0.354E-05	0.472	-0.397	0.833	553.0	-5.452	2.743
577.0	-2.721	0.716	0.816E-06	0.474	-0.405	0.832	577.0	-6.088	2.761
608.0	-2.778	0.725	0.189E-05	0.480	-0.413	0.839	608.0	-5.723	2.784
628.0	-2.782	0.730	0.163E-05	0.484	-0.414	0.847	628.0	-5.787	2.798
648.0	-2.783	0.731	0.619E-06	0.485	-0.414	0.850	648.0	-6.206	2.812
673.0	-2.790	0.740	0.245E-05	0.491	-0.415	0.863	673.0	-5.611	2.828
697.0	-2.847	0.748	0.217E-05	0.496	-0.423	0.869	697.0	-5.863	2.843
720.5	-2.851	0.754	0.168E-05	0.500	-0.424	0.878	720.5	-5.779	2.858
745.0	-2.907	0.761	0.187E-05	0.504	-0.432	0.883	745.0	-5.729	2.872
776.5	-2.914	0.770	0.186E-05	0.510	-0.433	0.888	776.5	-5.730	2.890
799.5	-2.915	0.772	0.568E-06	0.512	-0.434	0.899	799.5	-6.246	2.903
817.0	-2.919	0.777	0.186E-05	0.515	-0.434	0.907	817.0	-5.730	2.912

AYLIN EQUATION NUMBER 1

Y = -.2922440E-01 -5.311072 X + 1.887409 X**2 -.2598574 X**3

T-VALUES ARE : 10.4108 4.9328 3.2940

RSQUARE = 0.9892 STD. ERR. OF EST. = .1916709

LOAD INCREMENT # 3 S.D.= 392 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.1	-3.039	0.801	0.531E-01	0.531	-0.452	0.932	817.1	-1.275	-1.000
9.5	-3.263	1.120	0.226E-03	0.743	-0.485	1.425	826.5	-3.646	0.978
22.5	-3.410	1.286	0.750E-04	0.841	-0.507	1.646	839.5	-4.125	1.352
46.5	-3.629	1.416	0.415E-04	0.940	-0.540	1.863	863.5	-4.382	1.667
70.5	-3.752	1.508	0.257E-04	1.002	-0.558	1.998	887.5	-4.590	1.848
94.5	-3.858	1.578	0.194E-04	1.049	-0.574	2.100	911.5	-4.712	1.975
125.5	-3.916	1.650	0.157E-04	1.097	-0.583	2.212	942.5	-4.805	2.099
145.0	-3.939	1.680	0.101E-04	1.117	-0.586	2.257	962.0	-4.996	2.161
165.5	-4.016	1.713	0.109E-04	1.139	-0.598	2.303	982.6	-4.963	2.219
189.5	-4.040	1.743	0.848E-05	1.160	-0.601	2.349	1006.5	-5.071	2.278
213.6	-4.109	1.767	0.857E-05	1.175	-0.612	2.380	1030.5	-5.183	2.329
237.5	-4.127	1.780	0.630E-05	1.190	-0.614	2.414	1054.5	-5.201	2.376
261.5	-4.143	1.810	0.575E-05	1.204	-0.617	2.446	1078.5	-5.240	2.417
289.5	-4.180	1.831	0.493E-05	1.218	-0.619	2.478	1106.5	-5.307	2.462
319.5	-4.179	1.854	0.526E-05	1.234	-0.622	2.514	1136.6	-5.278	2.504
333.5	-4.205	1.862	0.375E-05	1.239	-0.626	2.524	1150.5	-6.426	2.523
357.5	-4.209	1.867	0.137E-05	1.242	-0.627	2.532	1174.5	-5.863	2.553
381.5	-4.227	1.890	0.630E-05	1.258	-0.629	2.567	1198.5	-5.201	2.581
405.5	-4.237	1.903	0.356E-05	1.266	-0.631	2.586	1222.5	-5.448	2.608
429.5	-4.227	1.915	0.356E-05	1.275	-0.629	2.608	1246.5	-5.448	2.633
454.5	-4.236	1.926	0.289E-05	1.282	-0.631	2.625	1271.5	-5.539	2.658
482.0	-4.246	1.939	0.311E-05	1.290	-0.632	2.645	1299.0	-5.508	2.683
508.0	-4.254	1.949	0.253E-05	1.297	-0.633	2.660	1325.0	-5.597	2.706
534.0	-4.262	1.959	0.253E-05	1.304	-0.634	2.675	1351.0	-5.597	2.728
552.0	-4.272	1.971	0.475E-05	1.312	-0.636	2.685	1369.0	-5.323	2.742
578.0	-4.277	1.978	0.177E-05	1.317	-0.637	2.705	1395.0	-5.752	2.762
605.5	-4.283	1.986	0.191E-05	1.322	-0.638	2.717	1422.5	-5.718	2.782
630.5	-4.278	2.004	0.474E-05	1.334	-0.637	2.747	1447.5	-5.324	2.800
653.5	-4.301	2.009	0.143E-05	1.337	-0.640	2.752	1470.5	-5.844	2.815
677.5	-4.311	2.020	0.329E-05	1.345	-0.642	2.771	1494.5	-5.483	2.831
717.5	-4.524	2.037	0.280E-05	1.356	-0.674	2.772	1534.5	-5.553	2.856
741.5	-4.532	2.047	0.274E-05	1.363	-0.675	2.787	1558.5	-6.562	2.870
765.5	-4.538	2.056	0.220E-05	1.368	-0.676	2.799	1582.5	-5.658	2.884
796.5	-4.646	2.065	0.212E-05	1.375	-0.692	2.802	1613.5	-5.673	2.901
816.5	-4.652	2.072	0.263E-05	1.380	-0.693	2.814	1633.5	-5.580	2.912
837.5	-4.656	2.077	0.157E-05	1.383	-0.693	2.822	1654.5	-5.804	2.923
862.5	-4.661	2.083	0.158E-05	1.387	-0.694	2.831	1679.5	-5.801	2.936
885.5	-4.666	2.089	0.172E-05	1.391	-0.695	2.840	1702.5	-5.766	2.947
909.5	-4.670	2.095	0.185E-05	1.395	-0.695	2.849	1726.5	-5.783	2.959
933.5	-4.675	2.101	0.165E-05	1.399	-0.696	2.858	1750.5	-5.783	2.970
965.5	-4.683	2.111	0.208E-05	1.406	-0.697	2.873	1782.5	-5.687	2.985
985.5	-4.687	2.116	0.165E-05	1.409	-0.698	2.881	1802.5	-5.783	2.994
1006.5	-4.689	2.119	0.988E-06	1.411	-0.698	2.886	1822.5	-6.005	3.002
1029.5	-4.695	2.125	0.192E-05	1.415	-0.699	2.895	1846.5	-5.717	3.013

AVLIN EQUATION NUMBER 2

Y = -2.434335 -1.200763 X -.2728175E-01 X**2 + .1815100E-01 X**3

T-VALUES ARE : 17.7362 0.2677 0.5815

RSQUARE = 0.9735 STD. ERR. OF EST. = .1326715

LOAD INCREMENT # 4 S.D.= 588 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.1	-4.802	2.180	0.144E+00	1.438	-0.730	2.827	1846.6	-0.842	-1.000
7.5	-4.804	2.602	0.401E-03	1.735	-0.730	3.854	1854.0	-3.397	0.875
23.0	-4.876	2.942	0.148E-03	1.965	-0.726	4.220	1869.6	-3.830	1.362
49.0	-4.809	3.297	0.920E-04	2.204	-0.716	4.814	1895.6	-4.036	1.890
71.0	-4.757	3.483	0.574E-04	2.330	-0.708	5.129	1917.5	-4.241	1.851
102.0	-4.714	3.680	0.429E-04	2.463	-0.702	5.461	1948.5	-4.368	2.009
122.5	-4.699	3.787	0.354E-04	2.536	-0.700	5.640	1969.0	-4.451	2.088
143.0	-4.670	3.875	0.292E-04	2.596	-0.680	5.803	1989.5	-4.534	2.155
167.0	-4.495	3.969	0.267E-04	2.680	-0.868	5.969	2013.5	-4.574	2.223
191.0	-4.463	4.055	0.242E-04	2.718	-0.864	6.115	2037.5	-4.617	2.281
215.0	-4.376	4.133	0.222E-04	2.771	-0.651	6.256	2061.5	-4.653	2.332
238.0	-4.333	4.206	0.206E-04	2.821	-0.645	6.382	2085.5	-4.686	2.378
264.0	-4.291	4.279	0.198E-04	2.870	-0.639	6.508	2110.5	-4.704	2.422
290.0	-4.262	4.354	0.198E-04	2.921	-0.633	6.639	2136.5	-4.704	2.462
311.0	-4.185	4.395	0.134E-04	2.950	-0.623	6.716	2157.5	-4.874	2.493
335.0	-4.128	4.449	0.153E-04	2.986	-0.614	6.813	2181.5	-4.815	2.525
359.0	-4.071	4.503	0.153E-04	3.023	-0.606	6.910	2205.5	-4.814	2.555
383.0	-4.013	4.556	0.151E-04	3.059	-0.597	7.006	2229.5	-4.822	2.583
407.0	-3.949	4.602	0.128E-04	3.090	-0.588	7.088	2253.5	-4.882	2.610
438.0	-3.892	4.656	0.115E-04	3.127	-0.579	7.186	2285.5	-4.939	2.642
457.0	-3.819	4.690	0.130E-04	3.150	-0.568	7.253	2303.5	-4.885	2.680
478.0	-3.806	4.736	0.143E-04	3.182	-0.566	7.331	2326.5	-4.844	2.680
503.0	-3.737	4.775	0.112E-04	3.209	-0.556	7.405	2349.5	-4.852	2.702
527.0	-3.716	4.811	0.101E-04	3.233	-0.553	7.467	2373.5	-4.998	2.722
551.0	-3.647	4.850	0.112E-04	3.260	-0.543	7.541	2397.5	-4.952	2.741
575.0	-3.583	4.885	0.129E-04	3.290	-0.533	7.625	2421.5	-4.891	2.760
600.5	-3.517	4.938	0.116E-04	3.320	-0.523	7.705	2447.0	-4.936	2.778
626.5	-3.452	4.982	0.114E-04	3.350	-0.514	7.785	2473.0	-4.845	2.797
647.5	-3.380	5.017	0.115E-04	3.374	-0.503	7.853	2494.0	-4.939	2.811
671.0	-3.361	5.056	0.114E-04	3.401	-0.500	7.921	2517.5	-4.942	2.827
695.0	-3.294	5.097	0.118E-04	3.429	-0.490	7.999	2541.5	-4.930	2.842
718.0	-3.173	5.134	0.108E-04	3.454	-0.472	8.074	2564.5	-4.986	2.856
743.0	-3.201	5.168	0.941E-05	3.477	-0.476	8.129	2589.5	-5.026	2.871
768.0	-3.127	5.201	0.914E-05	3.500	-0.465	8.194	2614.5	-5.039	2.885
797.0	-3.062	5.245	0.102E-04	3.530	-0.455	8.274	2643.5	-4.991	2.901
815.0	-3.080	5.268	0.897E-05	3.546	-0.458	8.311	2661.5	-5.047	2.911
839.0	-3.009	5.304	0.101E-04	3.570	-0.447	8.379	2685.5	-4.996	2.924
863.0	-2.934	5.335	0.897E-05	3.592	-0.436	8.441	2709.5	-5.047	2.936
887.0	-2.857	5.364	0.842E-05	3.612	-0.425	8.500	2733.5	-5.075	2.948
911.0	-2.846	5.414	0.140E-04	3.645	-0.423	8.584	2757.5	-4.853	2.960
937.0	-2.773	5.447	0.881E-05	3.668	-0.412	8.648	2783.5	-5.055	2.972
960.0	-2.750	5.480	0.995E-05	3.691	-0.409	8.708	2806.5	-5.002	2.982
983.0	-2.675	5.512	0.937E-05	3.713	-0.398	8.770	2829.5	-5.028	2.993
1007.0	-2.603	5.547	0.101E-04	3.737	-0.387	8.838	2853.5	-4.995	3.003
1031.0	-2.523	5.573	0.730E-05	3.755	-0.376	8.890	2877.5	-5.137	3.013
1055.0	-2.500	5.606	0.955E-05	3.777	-0.372	8.949	2901.5	-5.020	3.023
1079.0	-2.461	5.632	0.759E-05	3.796	-0.364	9.000	2925.5	-5.120	3.033
1105.0	-2.397	5.885	0.858E-05	3.818	-0.356	9.061	2851.5	-5.088	3.043
1129.0	-2.371	5.885	0.872E-05	3.839	-0.352	9.115	2975.5	-5.060	3.053
1151.0	-2.344	5.724	0.889E-05	3.858	-0.348	9.167	2897.5	-5.051	3.061
1175.0	-2.284	5.749	0.731E-05	3.876	-0.337	9.219	3021.5	-5.138	3.070
1199.0	-2.236	5.777	0.787E-05	3.895	-0.332	9.269	3045.5	-5.104	3.078
1223.0	-2.168	5.804	0.788E-05	3.914	-0.321	9.325	3089.5	-5.104	3.087
1247.0	-2.131	5.834	0.844E-05	3.934	-0.317	9.378	3093.5	-5.074	3.096
1272.0	-2.068	5.867	0.918E-05	3.957	-0.306	9.443	3118.5	-5.037	3.104
1296.0	-2.031	5.896	0.818E-05	3.977	-0.302	9.494	3142.5	-5.088	3.113
1319.0	-1.951	5.921	0.764E-05	3.994	-0.290	9.547	3165.5	-5.117	3.120
1343.0	-1.928	5.956	0.888E-05	4.018	-0.287	9.608	3189.5	-5.006	3.128
1367.0	-1.787	5.979	0.676E-05	4.034	-0.267	9.663	3213.5	-5.170	3.136
1391.0	-1.815	6.002	0.848E-05	4.050	-0.270	9.699	3237.5	-5.188	3.143
1415.0	-1.756	6.028	0.761E-05	4.068	-0.261	9.751	3261.5	-5.119	3.151
1440.0	-1.708	6.055	0.730E-05	4.086	-0.264	9.802	3286.5	-5.137	3.158
1468.0	-1.703	6.087	0.797E-05	4.108	-0.253	9.857	3314.5	-5.099	3.167
1487.0	-1.649	6.107	0.712E-05	4.122	-0.245	9.897	3333.5	-5.147	3.172
1511.0	-1.619	6.131	0.705E-05	4.139	-0.240	9.942	3357.5	-5.152	3.179
1535.0	-1.591	6.159	0.790E-05	4.158	-0.236	9.991	3381.5	-5.102	3.186
1559.0	-1.516	6.191	0.931E-05	4.180	-0.225	10.055	3405.5	-5.031	3.193
1583.0	-1.438	6.219	0.790E-05	4.199	-0.214	10.111	3429.5	-5.102	3.199
1608.0	-1.408	6.243	0.677E-05	4.216	-0.209	10.156	3454.5	-5.169	3.206
1632.0	-1.279	6.270	0.762E-05	4.234	-0.190	10.217	3478.5	-5.118	3.213
1655.0	-1.246	6.291	0.648E-05	4.249	-0.185	10.257	3501.5	-5.189	3.219
1679.0	-1.260	6.309	0.508E-05	4.261	-0.187	10.285	3525.5	-5.294	3.225
1703.0	-1.232	6.336	0.790E-05	4.280	-0.183	10.335	3549.5	-5.102	3.231
1727.0	-1.198	6.356	0.565E-05	4.294	-0.178	10.373	3573.5	-5.248	3.237
1751.0	-1.170	6.384	0.791E-05	4.313	-0.174	10.423	3597.5	-5.102	3.243
1776.0	-1.135	6.403	0.542E-05	4.326	-0.169	10.460	3622.5	-5.266	3.249
1804.0	-1.107	6.431	0.678E-05	4.345	-0.164	10.510	3650.5	-5.169	3.256
1823.0	-1.021	6.447	0.606E-05	4.357	-0.152	10.549	3669.5	-5.217	3.261
1848.0	-1.036	6.466	0.516E-05	4.370	-0.154	10.578	3694.5	-5.288	3.267
1871.0	-0.953	6.488	0.649E-05	4.385	-0.142	10.625	3717.5	-5.188	3.272
1895.0	-0.922	6.511	0.678E-05	4.401	-0.137	10.669	3741.5	-5.169	3.278
1924.0	-0.891	6.536	0.585E-05	4.418	-0.132	10.714	3770.5	-5.233	3.284
1944.5	-0.809	6.558	0.761E-05	4.434	-0.120	10.762	3791.0	-5.119	3.289
1969.0	-0.726	6.579	0.582E-05	4.448	-0.108	10.807	3815.5	-5.235	3.294
1991.0	-0.742	6.600	0.648E-05	4.462	-0.110	10.840	3837.5	-5.189	3.299
2015.0	-0.658	6.619	0.566E-05	4.476	-0.098	10.883	3861.5	-5.247	3.304
2039.0	-0.673	6.638	0.538E-05	4.489	-0.100	10.913	3885.5	-5.270	3.309
2063.0	-0.589	6.659	0.594E-05	4.503	-0.087	10.958	3909.5	-5.226	3.314
2087.0	-0.605	6.678	0.566E-05	4.516	-0.090	10.990	3933.5	-5.247	3.320
2113.0	-0.523	6.702	0.627E-05	4.533	-0.078	11.040	3959.5	-5.203	3.325
2144.0	-0.454	6.740	0.855E-05	4.559	-0.067	11.113	3990.5	-5.068	3.331

AVLIN EQUATION NUMBER 3

Y = -2.266588 -1.311101 X + .1124708 X**2 + .4810631E-02 X**3

T-VALUES ARE : 44.3691 3.5984 0.6986

RSQUARE = 0.9885 STD. ERR. OF EST. = .5788172E-01

PLOT 1, 194 UNPLOTTABLE POINTS

GEOTECHNICAL LABORATORIES
DEPARTMENT OF CIVIL ENGINEERING
UNIVERSITY OF MANITOBA

CONSTANT MEAN NORMAL STRESS MULTI-STAGE SHORT-TERM TRIAXIAL CREEP TEST
MST6 – σ_m=70 kPa

LOAD INCREMENT # 1 S.D.= 0 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	0.980	0.0	0.0	0.0	0.144	0.117	0.0	0.0	0.0
0.1	-1.122	0.003	0.333E-03	0.002	-0.165	0.129	0.1	-3.478	-1.097
0.6	-1.324	0.009	0.696E-04	0.006	-0.195	0.145	0.6	-4.157	-0.237
2.6	-1.382	0.027	0.610E-04	0.018	-0.203	0.122	2.6	-4.215	0.412
6.1	-1.482	0.027	0.0	0.018	-0.218	0.134	6.1	0.0	0.0
21.6	-1.716	0.036	0.412E-05	0.024	-0.253	0.146	21.6	-5.385	1.334
45.6	-2.034	0.031	-0.145E-05	0.021	-0.289	0.183	45.6	0.0	0.0
71.1	-2.234	0.031	0.0	0.021	-0.329	0.217	71.1	0.0	0.0
98.1	-2.336	0.035	0.861E-06	0.023	-0.344	0.224	98.1	-6.065	1.992
117.6	-2.387	0.038	0.119E-05	0.026	-0.352	0.224	117.6	-5.926	2.070
141.6	-2.436	0.036	-0.482E-06	0.024	-0.359	0.233	141.6	0.0	0.0
165.6	-2.467	0.037	0.243E-06	0.025	-0.366	0.238	165.6	-6.614	2.219
189.6	-2.488	0.040	0.725E-06	0.027	-0.366	0.234	189.6	-6.139	2.278
213.6	-2.539	0.042	0.725E-06	0.028	-0.374	0.236	213.6	-6.139	2.330
240.6	-2.639	0.043	0.212E-06	0.029	-0.389	0.246	240.6	-6.674	2.381
269.6	-2.690	0.044	0.201E-06	0.030	-0.396	0.251	269.6	-6.696	2.431
285.6	-2.691	0.046	0.727E-06	0.031	-0.396	0.248	285.6	-6.139	2.456
309.6	-2.741	0.047	0.243E-06	0.031	-0.404	0.253	309.6	-6.614	2.491
334.6	-2.736	0.036	-0.279E-05	0.024	-0.403	0.269	334.6	0.0	0.0
357.6	-2.738	0.041	0.126E-05	0.027	-0.403	0.262	357.6	-5.900	2.553
381.6	-2.738	0.041	0.0	0.027	-0.403	0.262	381.6	0.0	0.0
407.6	-2.788	0.042	0.449E-06	0.028	-0.411	0.286	407.6	-6.347	2.610
438.6	-2.887	0.038	-0.939E-06	0.026	-0.425	0.285	438.6	0.0	0.0
457.6	-2.792	0.049	0.398E-05	0.033	-0.411	0.255	457.6	-5.401	2.660
477.6	-2.841	0.046	-0.116E-05	0.031	-0.418	0.266	477.6	0.0	0.0
501.6	-3.035	0.034	-0.339E-05	0.023	-0.447	0.310	501.6	0.0	0.0
527.1	-2.935	0.033	-0.229E-06	0.022	-0.432	0.299	527.1	0.0	0.0
550.1	-2.834	0.032	-0.249E-06	0.021	-0.418	0.288	550.1	0.0	0.0
575.6	-2.839	0.042	0.250E-05	0.028	-0.418	0.273	575.6	-5.602	2.760
599.6	-2.742	0.048	0.194E-05	0.033	-0.404	0.250	599.6	-5.713	2.778
621.6	-2.743	0.052	0.105E-05	0.035	-0.404	0.245	621.6	-5.977	2.794
645.6	-2.743	0.052	0.0	0.035	-0.404	0.245	645.6	0.0	0.0
669.6	-2.743	0.052	0.0	0.035	-0.404	0.245	669.6	0.0	0.0
685.6	-2.739	0.042	-0.268E-05	0.028	-0.403	0.261	685.6	0.0	0.0
717.6	-2.740	0.045	0.106E-05	0.030	-0.404	0.256	717.6	-5.976	2.856
744.6	-2.743	0.052	0.172E-05	0.035	-0.404	0.245	744.6	-5.764	2.872
767.6	-2.843	0.051	-0.249E-06	0.034	-0.419	0.258	767.6	0.0	0.0
789.6	-2.744	0.053	0.526E-06	0.035	-0.404	0.243	789.6	-6.279	2.897

LOAD INCREMENT # 2 S.D.= 49 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	0.182	0.084	0.566E-01	0.057	0.027	0.181	0.0	-1.247	-2.000
0.1	0.182	0.085	0.835E-04	0.057	0.027	0.182	0.1	-4.078	-1.097
0.5	0.177	0.096	0.160E-03	0.085	0.026	0.180	0.5	-3.745	-0.301
1.5	0.269	0.114	0.115E-03	0.076	0.040	0.219	1.5	-3.935	0.176
3.5	0.170	0.112	-0.579E-05	0.075	0.025	0.205	3.5	0.0	0.0
5.5	0.171	0.108	-0.116E-04	0.073	0.025	0.199	5.5	-5.385	1.334
9.5	0.169	0.114	0.871E-05	0.076	0.025	0.207	9.5	-5.060	0.978
22.0	0.186	0.121	0.373E-05	0.081	0.024	0.218	22.0	-5.429	1.342

LOAD INCREMENT # 3 S.D.= 73 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	0.073	0.104	0.699E-01	0.070	0.011	0.180	22.0	-1.155	-2.000
0.1	0.076	0.099	-0.317E-03	0.066	0.011	0.172	22.1	-4.078	-1.097
0.4	0.074	0.102	0.926E-04	0.069	0.011	0.177	22.4	-4.034	-0.432
0.6	0.054	0.103	0.234E-04	0.069	0.008	0.176	22.6	-4.631	-0.208
1.1	0.053	0.105	0.234E-04	0.070	0.008	0.179	23.1	-4.631	0.049
2.1	0.053	0.105	0.0	0.070	0.008	0.179	24.1	-5.385	1.334
3.1	0.067	0.118	0.872E-04	0.079	0.010	0.202	25.1	-4.059	0.494
5.1	0.071	0.108	-0.320E-04	0.073	0.010	0.187	27.1	-5.429	1.342
7.1	0.072	0.108	-0.286E-05	0.072	0.010	0.186	29.1	-6.065	1.992
11.1	0.070	0.111	0.579E-05	0.075	0.010	0.191	33.1	-5.238	1.046
23.1	0.066	0.120	0.485E-05	0.080	0.010	0.205	45.1	-5.315	1.364

LOAD INCREMENT # 4 S.D.= 98 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	-0.103	0.095	0.641E-01	0.064	-0.015	0.145	45.1	-1.193	-2.000
0.1	-0.152	0.095	-0.818E-04	0.064	-0.023	0.137	45.2	-4.078	-1.097
0.3	-0.152	0.095	0.0	0.064	-0.023	0.137	45.4	-4.034	-0.432
0.6	-0.182	0.094	-0.234E-04	0.063	-0.027	0.132	45.7	-4.631	-0.208
1.1	-0.184	0.098	0.580E-04	0.066	-0.027	0.139	46.2	-4.237	0.033
2.1	-0.186	0.103	0.349E-04	0.069	-0.028	0.147	47.2	-4.457	0.318
3.1	-0.111	0.115	0.756E-04	0.077	-0.016	0.175	48.2	-4.122	0.489
5.1	-0.108	0.107	-0.262E-04	0.072	-0.016	0.163	50.2	-5.429	1.342
7.1	-0.108	0.107	0.0	0.072	-0.016	0.163	52.2	-6.065	1.992
12.1	-0.109	0.110	0.465E-05	0.074	-0.016	0.168	57.2	-5.332	1.082
23.1	-0.113	0.118	0.476E-05	0.079	-0.017	0.181	68.2	-5.323	1.363

LOAD INCREMENT # 5 S.D.= 122 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	-0.202	0.116	0.778E-01	0.078	-0.030	0.156	68.2	-1.110	-2.000
0.1	-0.200	0.111	-0.264E-03	0.075	-0.030	0.159	68.3	-4.078	-1.097
0.4	-0.200	0.111	0.0	0.075	-0.030	0.159	68.5	-4.034	-0.432
0.6	-0.220	0.111	0.0	0.075	-0.032	0.157	68.8	-4.631	-0.208
1.1	-0.200	0.112	0.117E-04	0.075	-0.030	0.160	69.3	-4.832	0.041
2.1	-0.200	0.112	0.0	0.075	-0.030	0.160	70.3	-4.457	0.318
3.1	-0.155	0.122	0.638E-04	0.082	-0.023	0.182	71.3	-4.195	0.491
5.1	-0.154	0.120	-0.579E-05	0.081	-0.023	0.179	73.3	-5.429	1.342
7.1	-0.154	0.120	0.0	0.081	-0.023	0.179	75.3	-6.065	1.992
24.1	-0.108	0.129	0.378E-05	0.087	-0.016	0.200	92.3	-5.425	1.382

LOAD INCREMENT # 6 S.D.= 147 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	-0.088	0.129	0.885E-01	0.086	-0.013	0.201	92.3	-1.063	-2.000
0.1	-0.088	0.130	0.650E-04	0.087	-0.013	0.203	92.4	-4.187	-1.000
0.3	-0.087	0.128	-0.688E-04	0.086	-0.013	0.200	92.6	-4.034	-0.432
0.5	-0.136	0.125	-0.697E-04	0.084	-0.020	0.190	92.8	-4.631	-0.208
0.8	-0.137	0.128	0.697E-04	0.086	-0.020	0.194	93.1	-4.157	-0.114
1.3	-0.137	0.128	0.0	0.086	-0.020	0.194	93.6	-4.457	0.318
2.3	-0.096	0.146	0.122E-03	0.098	-0.014	0.229	94.6	-3.913	0.356
4.3	-0.144	0.142	-0.146E-04	0.095	-0.021	0.216	96.6	-5.429	1.342
6.3	-0.143	0.141	-0.289E-05	0.095	-0.021	0.215	98.6	-6.065	1.992
9.8	-0.096	0.147	0.116E-04	0.099	-0.014	0.230	102.1	-4.935	0.990
22.8	-0.049	0.154	0.358E-05	0.103	-0.007	0.247	115.1	-5.446	1.357

LOAD INCREMENT # 7 S.D.= 171 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	0.301	0.153	0.103E+00	0.103	0.044	0.268	115.1	-0.988	-2.000
0.1	0.351	0.155	0.130E-03	0.104	0.052	0.297	115.2	-3.886	-1.000
0.4	0.333	0.148	-0.163E-03	0.100	0.049	0.285	115.4	-4.034	-0.432
0.6	0.332	0.151	0.463E-04	0.101	0.049	0.288	115.7	-4.334	-0.222
1.1	0.351	0.154	0.485E-04	0.103	0.052	0.296	116.2	-4.332	0.041
2.1	0.400	0.156	0.118E-04	0.105	0.059	0.304	117.2	-4.936	0.322
7.1	0.497	0.164	0.105E-04	0.110	0.073	0.328	122.2	-4.979	0.851
11.6	0.493	0.171	0.116E-04	0.115	0.073	0.341	126.7	-4.934	1.064
23.1	0.490	0.179	0.455E-05	0.120	0.072	0.354	138.2	-5.342	1.364
26.1	0.540	0.179	0.0	0.120	0.080	0.360	141.2	-4.935	0.990
31.1	0.540	0.179	0.0	0.120	0.080	0.360	146.2	-5.446	1.357
35.6	0.739	0.180	0.130E-05	0.121	0.109	0.385	150.7	-5.886	1.551
47.1	0.838	0.183	0.152E-05	0.123	0.124	0.401	162.2	-5.819	1.673
55.1	0.839	0.180	-0.218E-05	0.121	0.124	0.397	170.2	-6.139	2.330
59.1	0.888	0.183	0.436E-05	0.123	0.131	0.407	174.2	-5.361	1.772
71.1	0.836	0.188	0.290E-05	0.126	0.123	0.410	186.2	-5.537	1.852
78.1	0.836	0.188	0.0	0.126	0.123	0.410	193.2	-6.138	2.456
82.1	0.836	0.188	0.0	0.126	0.123	0.410	197.2	-6.614	2.491
94.1	0.834	0.191	0.193E-05	0.128	0.123	0.415	209.2	-5.713	1.974
102.1	0.884	0.191	0.0	0.128	0.130	0.421	217.2	-5.900	2.553
118.6	0.982	0.196	0.211E-05	0.132	0.145	0.441	233.7	-5.675	2.074
142.6	1.126	0.208	0.339E-05	0.140	0.166	0.479	257.7	-5.469	2.154
179.1	1.322	0.218	0.175E-05	0.147	0.195	0.518	294.2	-5.756	2.253
191.1	1.218	0.227	0.484E-05	0.152	0.180	0.520	306.2	-5.315	2.281
217.1	1.312	0.240	0.336E-05	0.161	0.194	0.553	332.2	-5.474	2.337
239.6	1.411	0.244	0.129E-05	0.164	0.208	0.571	354.7	-5.889	2.379
262.6	1.507	0.253	0.253E-05	0.170	0.222	0.597	377.7	-5.597	2.419
287.1	1.602	0.263	0.285E-05	0.177	0.236	0.626	402.2	-5.545	2.458
310.6	1.652	0.263	0.0	0.177	0.244	0.632	425.7	-5.802	2.760
337.1	1.597	0.275	0.307E-05	0.185	0.235	0.645	452.2	-5.513	2.528
360.1	1.595	0.279	0.101E-05	0.187	0.235	0.651	475.2	-5.995	2.556
383.1	1.639	0.292	0.379E-05	0.196	0.242	0.677	498.2	-5.421	2.583
407.1	1.638	0.294	0.729E-06	0.198	0.241	0.681	522.2	-6.137	2.610
431.1	1.585	0.301	0.184E-05	0.202	0.234	0.686	546.2	-5.712	2.635
455.1	1.684	0.303	0.485E-06	0.204	0.248	0.701	570.2	-6.314	2.658
478.1	1.731	0.308	0.177E-05	0.208	0.255	0.717	593.2	-5.752	2.680
505.1	1.777	0.318	0.237E-05	0.214	0.262	0.738	620.2	-6.625	2.703
530.1	1.864	0.348	0.792E-05	0.234	0.275	0.797	645.2	-5.101	2.724
551.1	1.974	0.326	-0.693E-05	0.219	0.291	0.775	666.2	0.0	0.0
575.1	2.072	0.329	0.727E-06	0.221	0.305	0.791	690.2	-6.139	2.760
599.1	2.072	0.330	0.483E-06	0.222	0.305	0.793	714.2	-6.316	2.777
623.1	2.067	0.340	0.267E-05	0.229	0.305	0.809	738.2	-5.574	2.795
647.1	2.163	0.349	0.267E-05	0.235	0.319	0.836	762.2	-5.573	2.811
672.6	2.180	0.357	0.205E-05	0.240	0.318	0.848	787.7	-5.687	2.828
697.6	2.305	0.368	0.303E-05	0.248	0.340	0.884	812.7	-5.519	2.844
719.1	2.350	0.378	0.298E-05	0.254	0.346	0.905	834.2	-5.526	2.857
746.1	2.438	0.406	0.690E-05	0.273	0.358	0.952	861.2	-5.161	2.873

GEOTECHNICAL LABORATORIES
DEPARTMENT OF CIVIL ENGINEERING
UNIVERSITY OF MANITOBA

CONSTANT MEAN NORMAL STRESS MULTI-STAGE SHORT-TERM TRIAXIAL CREEP TEST

MST7 – $\bar{\sigma}_m$=140 kPa

LOAD INCREMENT # 1 S.D.= 0 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	-2.343	0.054	0.365E-01	0.037	-0.346	0.193	0.0	-1.438	-2.000
0.3	-2.543	0.054	0.0	0.037	-0.376	0.217	0.3	0.0	0.0
0.5	-2.648	0.060	0.154E-03	0.040	-0.391	0.221	0.5	-3.812	-0.276
1.3	-2.842	0.052	-0.713E-04	0.035	-0.420	0.257	1.3	0.0	0.0
2.3	-2.992	0.052	0.0	0.035	-0.442	0.275	2.3	0.0	0.0
7.8	-3.146	0.058	0.701E-05	0.039	-0.465	0.284	7.8	-5.154	0.889
23.3	-3.409	0.073	0.661E-05	0.049	-0.504	0.291	23.3	-5.180	1.366
47.3	-3.712	0.078	0.134E-05	0.053	-0.549	0.318	47.3	-5.874	1.674
72.8	-4.015	0.081	0.751E-06	0.054	-0.594	0.351	72.8	-6.125	1.862
100.3	-4.172	0.091	0.233E-05	0.061	-0.617	0.355	100.3	-5.633	2.001
119.2	-4.276	0.095	0.169E-05	0.064	-0.632	0.359	119.2	-6.772	2.076
143.2	-4.380	0.100	0.134E-05	0.067	-0.648	0.364	143.2	-5.874	2.156
167.2	-4.485	0.107	0.187E-05	0.072	-0.663	0.366	167.2	-5.729	2.223
191.2	-4.590	0.113	0.161E-05	0.076	-0.679	0.369	191.2	-5.794	2.282
215.2	-4.692	0.115	0.800E-06	0.078	-0.694	0.377	215.2	-6.097	2.333
242.2	-4.795	0.119	0.948E-06	0.080	-0.709	0.383	242.2	-6.023	2.384
271.2	-5.000	0.125	0.133E-05	0.084	-0.740	0.398	271.2	-5.877	2.433
287.2	-5.052	0.128	0.120E-05	0.086	-0.748	0.400	287.2	-5.919	2.458
311.2	-5.103	0.129	0.268E-06	0.087	-0.755	0.405	311.2	-6.571	2.493
336.2	-5.195	0.118	-0.257E-05	0.080	-0.769	0.432	336.2	0.0	0.0
359.2	-5.250	0.125	0.167E-05	0.084	-0.777	0.429	359.2	-5.777	2.555
383.2	-5.347	0.121	-0.107E-05	0.081	-0.791	0.447	383.2	0.0	0.0
408.2	-5.445	0.119	-0.513E-06	0.080	-0.806	0.452	408.2	0.0	0.0
440.2	-5.541	0.114	-0.999E-06	0.077	-0.820	0.481	440.2	0.0	0.0
459.2	-5.508	0.135	0.742E-05	0.091	-0.815	0.443	459.2	-5.130	2.662
479.2	-5.595	0.119	-0.545E-05	0.080	-0.828	0.480	479.2	0.0	0.0
503.2	-5.845	0.119	0.0	0.080	-0.866	0.511	503.2	0.0	0.0
528.7	-5.686	0.108	-0.302E-05	0.072	-0.842	0.510	528.7	0.0	0.0
551.7	-5.735	0.107	-0.280E-06	0.072	-0.849	0.518	551.7	0.0	0.0
577.2	-5.739	0.112	0.126E-05	0.075	-0.850	0.510	577.2	-5.900	2.761
601.2	-5.696	0.120	0.241E-05	0.081	-0.843	0.491	601.2	-5.619	2.779
623.2	-5.744	0.117	-0.878E-06	0.079	-0.850	0.501	623.2	0.0	0.0
647.2	-5.799	0.124	0.187E-05	0.083	-0.859	0.487	647.2	-5.728	2.811
671.2	-5.846	0.120	-0.107E-05	0.081	-0.866	0.508	671.2	0.0	0.0
697.2	-5.890	0.113	-0.197E-05	0.076	-0.872	0.527	697.2	0.0	0.0
719.2	-5.891	0.114	0.290E-06	0.076	-0.872	0.525	719.2	-6.537	2.857
746.2	-5.944	0.117	0.948E-06	0.079	-0.880	0.526	746.2	-6.023	2.873
769.2	-6.047	0.122	0.140E-05	0.082	-0.896	0.530	769.2	-5.855	2.886
791.2	-5.949	0.124	0.583E-06	0.083	-0.881	0.515	791.2	-6.234	2.898

LOAD INCREMENT # 2 S.D.= 49 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	0.023	0.260	0.175E+00	0.175	0.003	0.432	0.0	-0.756	-2.000
0.1	0.021	0.262	0.183E-03	0.177	0.003	0.435	0.1	-3.737	-1.097
0.4	0.013	0.272	0.208E-03	0.184	0.002	0.451	0.4	-3.682	-0.377
1.4	0.042	0.298	0.174E-03	0.201	0.006	0.497	1.4	-3.760	0.152
3.4	-0.055	0.294	-0.129E-04	0.198	-0.008	0.479	3.4	0.0	0.0
5.4	-0.105	0.294	0.0	0.198	-0.016	0.473	5.4	-5.154	0.889
9.4	-0.109	0.300	0.966E-05	0.202	-0.016	0.482	9.4	-5.015	0.974
21.9	-0.169	0.313	0.669E-05	0.211	-0.025	0.495	21.9	-5.174	1.341

LOAD INCREMENT # 3 S.D.= 98 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	-0.236	0.296	0.200E+00	0.200	-0.035	0.460	21.9	-0.700	-2.000
0.1	-0.244	0.306	0.919E-03	0.206	-0.036	0.475	22.0	-3.037	-1.097
0.3	-0.238	0.298	-0.303E-03	0.201	-0.035	0.463	22.2	-3.682	-0.377
0.5	-0.268	0.298	0.0	0.201	-0.040	0.459	22.4	-3.760	0.152
1.0	-0.272	0.304	0.772E-04	0.205	-0.041	0.468	22.9	-4.113	0.0
2.0	-0.275	0.308	0.257E-04	0.207	-0.041	0.474	23.9	-4.589	0.301
3.0	-0.250	0.313	0.386E-04	0.211	-0.037	0.487	24.9	-4.414	0.477
5.0	-0.249	0.312	-0.317E-05	0.211	-0.037	0.485	26.9	-5.174	1.341
7.0	-0.249	0.312	0.0	0.211	-0.037	0.485	28.9	-6.125	1.862
11.0	-0.255	0.320	0.129E-04	0.216	-0.038	0.497	32.9	-4.891	1.041
23.0	-0.267	0.334	0.805E-05	0.225	-0.040	0.520	44.9	-5.094	1.362

LOAD INCREMENT # 4 S.D.= 147 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	-0.330	0.326	0.220E+00	0.220	-0.049	0.498	44.8	-0.658	-2.000
0.1	-0.330	0.326	0.0	0.220	-0.049	0.498	45.0	-3.037	-1.097
0.3	-0.331	0.328	0.516E-04	0.221	-0.049	0.501	45.2	-4.287	-0.481
0.6	-0.331	0.328	0.0	0.221	-0.049	0.501	45.5	-3.760	0.152
1.1	-0.337	0.335	0.989E-04	0.226	-0.050	0.513	46.0	-4.005	0.041
2.1	-0.345	0.345	0.844E-04	0.233	-0.051	0.528	47.0	-4.191	0.322
3.1	-0.355	0.357	0.837E-04	0.241	-0.053	0.547	48.0	-4.077	0.491
5.1	-0.403	0.355	-0.985E-05	0.239	-0.060	0.536	50.0	-5.174	1.341
7.1	-0.410	0.363	0.269E-04	0.245	-0.061	0.550	52.0	-4.538	0.851
12.1	-0.417	0.373	0.129E-04	0.251	-0.062	0.565	57.0	-4.890	1.083
23.1	-0.435	0.395	0.135E-04	0.266	-0.065	0.599	68.0	-4.871	1.364

LOAD INCREMENT # 5 S.D.= 196 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	-0.564	0.394	0.266E+00	0.266	-0.084	0.583	68.0	-0.575	-2.000
0.1	-0.568	0.398	0.536E-03	0.269	-0.085	0.590	68.1	-3.271	-1.155
0.3	-0.568	0.398	0.0	0.269	-0.085	0.590	68.3	-4.287	-0.481
0.6	-0.570	0.401	0.514E-04	0.270	-0.085	0.593	68.6	-4.288	-0.244
1.1	-0.576	0.408	0.103E-03	0.276	-0.086	0.605	69.1	-3.986	0.029
2.1	-0.580	0.414	0.375E-04	0.279	-0.086	0.614	70.1	-4.426	0.322
3.1	-0.592	0.429	0.988E-04	0.289	-0.088	0.636	71.1	-4.015	0.491
5.1	-0.598	0.437	0.290E-04	0.295	-0.089	0.649	73.1	-4.538	0.708
7.1	-0.605	0.445	0.258E-04	0.300	-0.090	0.661	75.1	-4.588	0.851
24.1	-0.643	0.493	0.190E-04	0.332	-0.096	0.736	92.1	-4.722	1.382

LOAD INCREMENT # 6 S.D.= 245 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	-0.768	0.499	0.337E+00	0.337	-0.114	0.731	92.1	-0.473	-2.000
0.1	-0.769	0.501	0.184E-03	0.338	-0.115	0.734	92.2	-3.736	-1.097
0.2	-0.771	0.503	0.144E-03	0.339	-0.115	0.737	92.3	-3.843	-0.770
0.4	-0.821	0.503	0.0	0.339	-0.122	0.731	92.5	-4.289	-0.244
0.7	-0.826	0.509	0.155E-03	0.343	-0.123	0.740	92.8	-3.811	-0.174
1.2	-0.832	0.516	0.103E-03	0.348	-0.124	0.752	93.3	-3.987	0.068
2.2	-0.802	0.542	0.189E-03	0.366	-0.119	0.798	94.3	-3.772	0.342
4.2	-0.812	0.554	0.419E-04	0.374	-0.121	0.817	96.3	-4.378	0.623
6.2	-0.826	0.572	0.580E-04	0.386	-0.123	0.844	98.3	-4.236	0.792
9.7	-0.847	0.598	0.516E-04	0.404	-0.126	0.886	101.8	-4.288	0.987
22.7	-0.894	0.658	0.308E-04	0.444	-0.133	0.978	114.8	-4.512	1.356

LOAD INCREMENT # 7 S.D.= 294 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	-0.999	0.663	0.447E+00	0.447	-0.149	0.974	114.8	-0.348	-2.000
0.1	-1.005	0.672	0.830E-03	0.453	-0.150	0.988	114.9	-3.081	-1.097
0.3	-1.035	0.672	0.0	0.453	-0.154	0.984	115.1	-3.843	-0.770
0.5	-1.039	0.675	0.103E-03	0.456	-0.155	0.990	115.3	-3.986	-0.301
1.0	-1.048	0.687	0.155E-03	0.463	-0.156	1.008	115.8	-3.810	0.0
2.0	-1.029	0.701	0.988E-04	0.473	-0.153	1.034	116.8	-4.014	0.301
7.0	-1.030	0.765	0.865E-04	0.516	-0.153	1.140	121.8	-4.063	0.845
11.5	-1.063	0.806	0.617E-04	0.544	-0.158	1.204	126.3	-4.210	1.061
23.0	-1.120	0.878	0.421E-04	0.593	-0.167	1.315	137.8	-4.375	1.362

LOAD INCREMENT # 8 S.D.= 343 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	0.842	0.888	0.600E+00	0.600	0.125	1.571	137.8	-0.222	-2.000
0.3	0.941	0.889	0.267E-04	0.600	0.140	1.584	138.1	-4.573	-0.602
0.5	0.935	0.897	0.207E-03	0.605	0.139	1.596	138.3	-3.685	-0.301
2.3	0.913	0.924	0.107E-03	0.624	0.136	1.640	140.1	-3.970	0.352
7.3	1.154	0.999	0.101E-03	0.675	0.171	1.792	145.1	-3.996	0.860
10.8	1.313	1.050	0.998E-04	0.709	0.195	1.897	148.6	-4.001	1.031
22.3	1.439	1.143	0.546E-04	0.772	0.214	2.086	160.1	-4.263	1.347
30.3	1.455	1.186	0.364E-04	0.801	0.216	2.139	168.1	-4.439	1.481
46.3	1.442	1.264	0.332E-04	0.854	0.214	2.268	184.1	-4.479	1.665
58.3	1.450	1.316	0.287E-04	0.890	0.215	2.356	196.1	-4.527	1.785
70.3	1.507	1.371	0.308E-04	0.927	0.224	2.454	208.1	-4.512	1.847
94.8	1.737	1.458	0.244E-04	0.987	0.258	2.628	232.6	-4.613	1.977
118.7	1.929	1.531	0.205E-04	1.036	0.287	2.772	256.6	-4.687	2.075
155.2	2.407	1.622	0.169E-04	1.098	0.357	2.961	293.1	-4.772	2.191
167.2	2.232	1.653	0.179E-04	1.119	0.332	3.012	305.1	-4.748	2.223
193.2	2.327	1.722	0.180E-04	1.166	0.346	3.138	331.1	-4.745	2.286
215.7	2.534	1.776	0.165E-04	1.203	0.376	3.254	353.6	-4.783	2.334
238.7	2.686	1.836	0.178E-04	1.244	0.399	3.373	376.6	-4.749	2.378
263.2	2.835	1.900	0.178E-04	1.287	0.421	3.497	401.1	-4.750	2.420
286.7	2.941	1.956	0.161E-04	1.325	0.436	3.603	424.6	-4.794	2.458
313.2	2.740	2.019	0.165E-04	1.369	0.407	3.685	451.1	-4.784	2.496
336.2	2.735	2.088	0.204E-04	1.416	0.406	3.799	474.1	-4.681	2.527
360.2	2.841	2.144	0.157E-04	1.454	0.422	3.905	498.1	-4.803	2.557
384.2	2.993	2.204	0.171E-04	1.495	0.444	4.024	522.1	-4.767	2.585
408.2	2.992	2.268	0.182E-04	1.538	0.444	4.131	546.1	-4.740	2.611
432.2	3.091	2.331	0.182E-04	1.582	0.459	4.250	570.1	-4.740	2.636
455.7	3.240	2.395	0.186E-04	1.626	0.481	4.375	593.6	-4.730	2.659
482.2	3.384	2.466	0.182E-04	1.674	0.502	4.511	620.1	-4.739	2.683
507.2	3.612	2.557	0.248E-04	1.736	0.536	4.690	645.1	-4.605	2.705
528.2	3.880	2.596	0.128E-04	1.763	0.576	4.788	666.1	-4.894	2.723
552.2	4.120	2.671	0.215E-04	1.815	0.611	4.944	690.1	-4.667	2.742
576.2	4.165	2.741	0.199E-04	1.862	0.618	5.066	714.1	-4.701	2.761
600.2	4.402	2.819	0.224E-04	1.916	0.653	5.225	738.1	-4.650	2.778
624.2	4.434	2.905	0.245E-04	1.975	0.657	5.374	762.1	-4.610	2.795
649.2	4.573	2.981	0.210E-04	2.027	0.678	5.520	787.1	-4.678	2.812
674.7	4.912	3.058	0.206E-04	2.080	0.728	5.689	812.6	-4.687	2.829
691.7	5.003	3.132	0.301E-04	2.131	0.742	5.825	829.6	-4.521	2.840
718.7	5.262	3.246	0.292E-04	2.210	0.780	6.049	856.6	-4.535	2.857

GEOTECHNICAL LABORATORIES
DEPARTMENT OF CIVIL ENGINEERING
UNIVERSITY OF MANITOBA

CONSTANT MEAN NORMAL STRESS MULTI-STAGE SHORT-TERM TRIAXIAL CREEP TEST
MST8 – $\bar{\sigma}_m$=280 kPa

LOAD INCREMENT # 1 S.D.= 0 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (MM/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	-4.004	0.268	0.180E+00	0.180	-0.593	0.044	0.0	-0.746	-2.000
0.3	-4.154	0.011	-0.719E-02	0.007	-0.615	0.484	0.3	0.0	0.0
0.5	-4.197	-0.009	-0.517E-03	-0.006	-0.621	0.521	0.5	0.0	0.0
2.0	-4.282	-0.022	-0.579E-04	-0.014	-0.635	0.554	2.0	0.0	0.0
7.0	-4.309	-0.029	-0.992E-05	-0.019	-0.638	0.568	7.0	0.0	0.0
11.0	-4.341	-0.023	0.107E-04	-0.015	-0.643	0.562	11.0	-4.970	1.041
23.0	-4.447	-0.009	0.779E-05	-0.008	-0.658	0.552	23.0	-5.109	1.362
30.0	-4.444	-0.014	-0.531E-05	-0.009	-0.658	0.560	30.0	0.0	0.0
48.0	-4.597	-0.007	0.275E-05	-0.004	-0.681	0.567	48.0	-5.560	1.681
80.0	-4.869	0.048	0.114E-04	0.032	-0.721	0.510	80.0	-4.943	1.903
98.0	-4.755	0.013	-0.124E-04	0.008	-0.704	0.554	98.0	0.0	0.0
119.0	-4.810	0.026	0.465E-05	0.018	-0.712	0.538	119.0	-5.333	2.076
143.0	-5.302	0.134	0.300E-04	0.090	-0.785	0.422	143.0	-4.523	2.155
168.5	-4.994	0.087	-0.122E-04	0.059	-0.740	0.460	168.5	0.0	0.0
191.5	-5.020	0.181	0.272E-04	0.121	-0.744	0.310	191.5	-4.565	2.282
217.0	-4.973	0.188	0.195E-05	0.126	-0.737	0.292	217.0	-5.710	2.336
241.0	-4.977	0.197	0.258E-05	0.132	-0.737	0.277	241.0	-5.588	2.382
263.0	-4.977	0.198	0.265E-06	0.133	-0.737	0.276	263.0	-6.545	2.420
287.0	-4.976	0.196	-0.778E-06	0.131	-0.737	0.280	287.0	0.0	0.0
311.0	-4.977	0.199	0.103E-05	0.134	-0.737	0.274	311.0	-5.985	2.493
337.0	-5.027	0.197	-0.477E-06	0.132	-0.744	0.283	337.0	0.0	0.0
359.0	-5.026	0.196	-0.564E-06	0.131	-0.744	0.286	359.0	0.0	0.0
386.0	-4.877	0.198	0.692E-06	0.133	-0.737	0.276	386.0	-6.160	2.587
409.0	-5.179	0.203	0.135E-05	0.136	-0.767	0.293	409.0	-5.871	2.612
431.0	-4.980	0.206	0.846E-06	0.138	-0.738	0.264	431.0	-6.072	2.634

LOAD INCREMENT # 3 S.D.= 147 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (MM/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	0.007	0.316	0.213E+00	0.213	0.001	0.522	23.5	-0.672	-2.000
0.1	0.007	0.318	0.177E-03	0.214	0.001	0.525	23.6	-3.751	-1.097
0.3	-0.041	0.313	-0.149E-03	0.210	-0.006	0.510	23.8	-3.534	-0.802
0.6	-0.094	0.320	0.199E-03	0.215	-0.014	0.515	24.1	-3.702	-0.237
0.8	-0.145	0.323	0.748E-04	0.217	-0.022	0.514	24.3	-4.126	-0.081
1.3	-0.169	0.332	0.124E-03	0.223	-0.025	0.526	24.8	-3.906	0.124
2.3	-0.170	0.335	0.187E-04	0.225	-0.025	0.531	25.8	-4.728	0.367
3.3	-0.152	0.339	0.311E-04	0.228	-0.023	0.540	26.8	-4.507	0.522
5.3	-0.103	0.343	0.124E-04	0.231	-0.015	0.552	28.8	-4.906	0.727
7.3	-0.101	0.338	-0.156E-04	0.228	-0.015	0.545	30.8	-4.963	1.041
11.3	-0.103	0.344	0.935E-05	0.231	-0.015	0.554	34.8	-5.029	1.054
23.3	-0.110	0.362	0.984E-05	0.243	-0.016	0.582	46.8	-5.007	1.368

AVLIN EQUATION NUMBER 2

Y = -4.210072 -.5408115 X + .1322600 X**2 -.2246729 X**3

T-VALUES ARE . 2.1124 0.8927 1.8553
RSQUARE = 0.9382 STD. ERR. OF EST. = .3517765

LOAD INCREMENT # 2 S.D.= 73 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (MM/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	-0.031	0.286	0.192E+00	0.192	-0.005	0.467	0.0	-0.716	-2.000
0.1	-0.061	0.286	0.0	0.192	-0.009	0.464	0.1	0.0	0.0
0.3	-0.064	0.293	0.292E-03	0.197	-0.012	0.473	0.3	-3.534	-0.602
0.5	-0.087	0.303	0.249E-03	0.203	-0.013	0.488	0.5	-3.604	-0.301
1.0	-0.131	0.285	-0.236E-03	0.192	-0.019	0.454	1.0	0.0	0.0
2.0	-0.285	0.295	0.684E-04	0.198	-0.042	0.462	2.0	-4.165	0.301
3.0	-0.242	0.315	0.131E-03	0.212	-0.036	0.489	3.0	-3.884	0.477
5.0	-0.140	0.310	-0.156E-04	0.208	-0.021	0.493	5.0	0.0	0.0
7.0	-0.091	0.312	0.621E-05	0.210	-0.014	0.503	7.0	-5.207	0.845
11.0	0.007	0.318	0.108E-04	0.214	0.001	0.525	11.0	-4.963	1.041
23.5	0.001	0.331	0.697E-05	0.223	0.000	0.546	23.5	-5.157	1.371

AVLIN EQUATION NUMBER 1

Y = -2.180993 -1.026749 X -.8716336 X**2 -.3382593 X**3

T-VALUES ARE : 0.5191 0.9569 0.3984
RSQUARE = 0.4523 STD. ERR. OF EST. = 1.939934

LOAD INCREMENT # 4 S.D.= 220 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (MM/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	-0.120	0.360	0.242E+00	0.242	-0.018	0.579	46.8	-0.616	-2.000
0.1	-0.172	0.366	0.748E-03	0.246	-0.026	0.582	46.9	-3.126	-1.222
0.4	-0.175	0.374	0.165E-03	0.252	-0.026	0.585	47.2	-3.783	-0.398
1.4	-0.266	0.402	0.187E-03	0.270	-0.040	0.630	48.2	-3.729	0.146
2.4	-0.280	0.411	0.623E-04	0.277	-0.043	0.642	49.2	-4.206	0.380
3.4	-0.283	0.421	0.684E-04	0.283	-0.036	0.685	50.2	-4.165	0.531
5.4	-0.285	0.428	0.218E-04	0.288	-0.037	0.675	52.2	-4.662	0.732
7.4	-0.289	0.436	0.280E-04	0.293	-0.037	0.688	54.2	-4.553	0.869
12.4	-0.258	0.458	0.299E-04	0.308	-0.038	0.724	59.2	-4.525	1.093
23.4	-0.265	0.478	0.119E-04	0.321	-0.038	0.755	70.2	-4.925	1.369

AYLIN EQUATION NUMBER 3

Y = -4.021373 -.3324787 X + .1027710 X**2 -.2837894 X**3

T-VALUES ARE : 1.8400 1.0421 3.4725
RSQUARE = 0.9774 STD. ERR. OF EST. = .2285523

LOAD INCREMENT # 5 S.D.= 294 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (MM/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	-0.263	0.473	0.318E+00	0.318	-0.039	0.747	70.2	-0.498	-2.000
0.1	-0.264	0.474	0.179E-03	0.319	-0.039	0.750	70.3	-3.746	-1.097
0.3	-0.289	0.487	0.348E-03	0.328	-0.043	0.768	70.6	-3.458	-0.481
0.6	-0.290	0.491	0.995E-04	0.330	-0.043	0.774	70.8	-4.002	-0.237
0.8	-0.312	0.496	0.125E-03	0.333	-0.046	0.779	71.1	-3.904	-0.081
1.3	-0.344	0.501	0.749E-04	0.337	-0.051	0.784	71.6	-4.126	0.124
2.3	-0.397	0.507	0.373E-04	0.341	-0.059	0.787	72.6	-4.428	0.367
3.3	-0.401	0.517	0.685E-04	0.348	-0.060	0.803	73.6	-4.164	0.522
5.3	-0.403	0.524	0.249E-04	0.353	-0.060	0.815	75.6	-4.603	0.727
7.3	-0.404	0.526	0.622E-05	0.354	-0.060	0.818	77.6	-5.206	0.865
24.3	-0.426	0.582	0.220E-04	0.391	-0.063	0.907	94.6	-4.658	1.386

AYLIN EQUATION NUMBER 4

Y = -4.181327 -.4472888 X + .2214018 X**2 -.2203997 X**3

T-VALUES ARE : 1.4031 1.2497 1.5265
RSQUARE = 0.9159 STD. ERR. OF EST = .4242845

LOAD INCREMENT # 6 S.D.= 367 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (MM/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	-0.334	0.577	0.388E+00	0.388	-0.050	0.910	94.6	-0.411	-2.000
0.1	-0.334	0.577	0.0	0.388	-0.050	0.910	94.6	-3.746	-1.097
0.3	-0.387	0.585	0.224E-03	0.394	-0.058	0.917	94.9	-3.649	-0.481
0.6	-0.387	0.585	0.0	0.394	-0.058	0.917	95.1	-4.002	-0.237
0.8	-0.438	0.588	0.749E-04	0.395	-0.065	0.915	95.4	-4.125	-0.081
1.1	-0.469	0.591	0.922E-04	0.398	-0.073	0.915	95.7	-4.035	0.041
1.6	-0.491	0.596	0.624E-04	0.401	-0.073	0.923	96.2	-4.205	0.204
2.6	-0.517	0.611	0.997E-04	0.411	-0.077	0.944	97.2	-4.001	0.415
4.6	-0.500	0.619	0.280E-04	0.417	-0.074	0.960	99.2	-4.552	0.663
6.6	-0.506	0.635	0.529E-04	0.427	-0.075	0.985	101.2	-4.276	0.820
10.1	-0.459	0.641	0.125E-04	0.432	-0.068	1.001	104.7	-4.904	1.004
23.1	-0.522	0.675	0.177E-04	0.455	-0.078	1.050	117.7	-4.751	1.364

AYLIN EQUATION NUMBER 5

Y = -4.126232 -.1542941 X + .1232253 X**2 -.3529629 X**3

T-VALUES ARE : 0.7268 1.0220 3.5463
RSQUARE = 0.9568 STD. ERR. OF EST. = .2821130

LOAD INCREMENT # 7 S.D.= 441 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (MM/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	-0.562	0.676	0.455E+00	0.455	-0.084	1.047	117.7	-0.342	-2.000
0.1	-0.464	0.681	0.446E-03	0.458	-0.069	1.066	117.7	-3.351	-1.097
0.3	-0.515	0.684	0.110E-03	0.460	-0.077	1.065	117.8	-3.959	-0.602
0.5	-0.516	0.685	0.249E-04	0.461	-0.077	1.066	118.2	-4.604	-0.301
0.8	-0.539	0.694	0.248E-03	0.467	-0.080	1.078	118.4	-3.603	-0.125
1.3	-0.621	0.698	0.624E-04	0.470	-0.092	1.076	118.9	-4.205	0.097
2.3	-0.624	0.707	0.561E-04	0.476	-0.093	1.090	119.8	-4.251	0.352
7.3	-0.637	0.741	0.461E-04	0.499	-0.095	1.144	124.8	-4.336	0.860
11.8	-0.625	0.761	0.305E-04	0.513	-0.093	1.179	129.4	-4.516	1.070
23.3	-0.660	0.798	0.217E-04	0.537	-0.098	1.236	140.9	-4.664	1.366

AYLIN EQUATION NUMBER 6

Y = -4.184645 -.8811235E-01 X + .2349831 X**2 -.3400687 X**3

T-VALUES ARE : 0.3587 1.6604 2.9572
RSQUARE = 0.9618 STD. ERR. OF EST. = .3066791

LOAD INCREMENT # 8 S.D = 514 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (MM/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	-0.727	0.790	0.532E+00	0.532	-0.108	1.216	140.8	-0.274	-2.000
0.1	-0.727	0.790	0.0	0.532	-0.108	1.216	141.0	-3.351	-1.097
0.3	-0.728	0.794	0.147E-03	0.535	-0.108	1.222	141.2	-3.832	-0.602
0.4	-0.728	0.795	0.363E-04	0.535	-0.108	1.223	141.3	-4.440	-0.377
0.7	-0.742	0.805	0.274E-03	0.542	-0.110	1.238	141.6	-3.562	-0.174
0.9	-0.755	0.813	0.200E-03	0.547	-0.112	1.249	141.8	-3.699	-0.036
1.4	-0.767	0.816	0.499E-04	0.550	-0.114	1.254	142.3	-4.302	0.152
2.4	-0.840	0.825	0.562E-04	0.555	-0.125	1.258	143.3	-4.251	0.384
7.4	-0.755	0.863	0.524E-04	0.582	-0.112	1.333	148.3	-4.281	0.870
11.9	-0.765	0.888	0.375E-04	0.598	-0.114	1.373	152.8	-4.427	1.078
23.4	-0.782	0.933	0.261E-04	0.628	-0.116	1.444	164.3	-4.584	1.370

AYLIN EQUATION NUMBER 7

Y = -4.078146 -.9819311E-01 X + .2164536 X**2 -.3390687 X**3

T-VALUES ARE : 0.4046 1.5672 2.9860
RSQUARE = 0.9541 STD. ERR. OF EST. = .3109382

LOAD INCREMENT # 9 S.D.= 588 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (MM/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	-0.782	0.933	0.628E+00	0.628	-0.116	1.444	164.3	-0.202	-2.000
0.1	-0.784	0.939	0.625E-03	0.633	-0.117	1.454	164.4	-3.204	-1.097
0.3	-0.786	0.943	0.998E-04	0.635	-0.117	1.460	164.7	-4.001	-0.481
0.6	-0.790	0.954	0.300E-03	0.643	-0.118	1.478	164.9	-3.523	-0.237
1.1	-0.814	0.964	0.132E-03	0.650	-0.121	1.492	165.4	-3.879	0.041
1.6	-0.847	0.970	0.875E-04	0.654	-0.126	1.499	165.9	-4.058	0.204
2.6	-0.851	0.982	0.749E-04	0.661	-0.127	1.517	166.9	-4.126	0.415
4.6	-0.858	0.999	0.594E-04	0.673	-0.128	1.545	168.9	-4.226	0.663
7.6	-0.873	1.038	0.875E-04	0.700	-0.130	1.607	171.9	-4.058	0.881
11.6	-0.888	1.077	0.656E-04	0.726	-0.132	1.670	175.9	-4.183	1.064
23.6	-0.986	1.151	0.417E-04	0.776	-0.144	1.783	187.9	-4.380	1.373

AYLIN EQUATION NUMBER 8

Y = -3.982222 -.1608195 X + .2785817 X**2 -.2889426 X**3

T-VALUES ARE : 1.0657 3.2927 4.1366
RSQUARE = 0.9804 STD ERR. OF EST. = .1978319

LOAD INCREMENT #10 S.D.= 661 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (MM/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	0.105	1.148	0.774E+00	0.774	0.016	1.908	187.9	-0.111	-2.000
0.1	0.104	1.150	0.180E-03	0.775	0.015	1.911	188.0	-3.744	-1.097
0.3	0.082	1.155	0.220E-03	0.779	0.012	1.917	188.2	-3.657	-0.602
0.4	0.048	1.163	0.331E-03	0.784	0.007	1.927	188.4	-3.480	-0.377
0.9	-0.055	1.174	0.138E-03	0.791	-0.008	1.931	188.9	-3.861	-0.036
1.4	-0.159	1.183	0.125E-03	0.798	-0.024	1.934	189.4	-3.902	0.152
2.4	-0.182	1.192	0.625E-04	0.804	-0.027	1.947	190.4	-4.204	0.364
7.4	-0.093	1.271	0.106E-03	0.857	-0.014	2.088	195.4	-3.973	0.870
11.4	-0.108	1.310	0.673E-04	0.884	-0.016	2.152	199.4	-4.172	1.058
23.4	0.135	1.404	0.527E-04	0.947	0.020	2.336	211.4	-4.278	1.370

AYLIN EQUATION NUMBER 9

Y = -3.931531 + .8500993E-01 X + .2067547 X**2 -.3836039 X**3

T-VALUES ARE : 0.3500 1.4560 3.3686

RSQUARE = 0.9571 STD. ERR. OF EST. = .3121578

LOAD INCREMENT #11 S.D.= 686 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (MM/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	2.175	1.404	0.947E+00	0.947	0.323	2.584	211.4	-0.024	-2.000
0.2	2.156	1.403	-0.295E-04	0.947	0.320	2.580	211.6	-3.744	-1.097
1.2	2.249	1.419	0.113E-03	0.958	0.334	2.619	212.6	-3.948	0.086
2.7	2.245	1.431	0.550E-04	0.966	0.333	2.638	214.1	-4.259	0.431
4.7	2.337	1.451	0.658E-04	0.979	0.347	2.681	216.1	-4.182	0.672
7.7	2.429	1.473	0.501E-04	0.994	0.360	2.729	219.1	-4.300	0.886
24.2	2.729	1.600	0.524E-04	1.081	0.405	2.978	235.6	-4.280	1.384
35.9	2.905	1.682	0.358E-04	1.123	0.431	3.102	247.3	-4.446	1.556
47.7	3.080	1.726	0.369E-04	1.166	0.457	3.229	259.0	-4.433	1.679
84.2	3.585	1.843	0.217E-04	1.245	0.531	3.484	295.5	-4.664	1.925
96.2	3.273	1.875	0.183E-04	1.267	0.485	3.500	307.5	-4.737	1.983
122.2	3.448	1.940	0.169E-04	1.311	0.511	3.629	333.5	-4.771	2.087
144.7	3.713	1.977	0.112E-04	1.336	0.550	3.723	356.0	-4.952	2.160
167.7	3.820	2.011	0.101E-04	1.360	0.566	3.792	379.0	-4.995	2.225
192.2	3.983	2.055	0.123E-04	1.390	0.590	3.886	403.5	-4.909	2.284
215.7	4.036	2.088	0.129E-04	1.420	0.598	3.966	427.0	-4.891	2.334
242.2	3.714	2.154	0.140E-04	1.457	0.551	4.018	453.5	-4.853	2.384
265.2	3.645	2.203	0.145E-04	1.490	0.540	4.092	476.5	-4.838	2.424
288.2	3.635	2.231	0.822E-05	1.509	0.539	4.137	499.5	-5.085	2.460
312.2	3.625	2.256	0.709E-05	1.526	0.537	4.178	523.5	-5.149	2.494
336.2	3.512	2.290	0.971E-05	1.550	0.520	4.221	547.5	-5.013	2.527
360.2	3.556	2.305	0.420E-05	1.560	0.527	4.251	571.5	-5.376	2.557
383.7	3.642	2.341	0.107E-04	1.585	0.540	4.323	595.0	-4.969	2.584
410.2	3.676	2.382	0.105E-04	1.613	0.545	4.395	621.5	-4.980	2.613
435.2	3.957	2.431	0.134E-04	1.646	0.586	4.511	646.5	-4.874	2.639
456.2	4.254	2.439	0.240E-05	1.651	0.630	4.559	667.5	-5.620	2.659
480.2	4.443	2.466	0.789E-05	1.670	0.658	4.628	691.5	-5.103	2.681
504.2	4.036	2.485	0.528E-05	1.683	0.598	4.610	715.5	-5.279	2.703
528.2	4.232	2.496	0.315E-05	1.690	0.627	4.652	739.5	-5.501	2.723
552.2	4.118	2.531	0.100E-04	1.714	0.610	4.697	763.5	-5.000	2.742
577.7	4.011	2.549	0.495E-05	1.727	0.594	4.715	789.0	-5.305	2.762
602.7	4.402	2.572	0.631E-05	1.743	0.652	4.801	814.0	-5.200	2.780
624.2	4.341	2.600	0.881E-05	1.762	0.643	4.840	835.5	-5.055	2.795
651.2	4.466	2.665	0.164E-04	1.806	0.662	4.964	862.5	-4.786	2.814

AYLIN EQUATION NUMBER 10

Y = -4.226858 -.5060314 X + .4360352 X**2 -.1415045 X**3

T-VALUES ARE : 4.7898 8.0065 5.7273

RSQUARE = 0.9249 STD. ERR. OF EST. = .2669781

PLOT 1, 1425 UNPLOTTABLE POINTS

GEOTECHNICAL LABORATORIES
DEPARTMENT OF CIVIL ENGINEERING
UNIVERSITY OF MANITOBA

CONSTANT MEAN NORMAL STRESS MULTI-STAGE SHORT-TERM TRIAXIAL CREEP TEST
MST9 – σ_m=420 kPa

LOAD INCREMENT # 1 S.D.= 0 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (MM/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	-4.073	0.008	0.574E-02	0.006	-0.619	0.491	0.0	-2.241	-2.000
0.1	-4.073	0.008	0.0	0.006	-0.619	0.491	0.1	0.0	0.0
0.6	-4.223	0.008	0.0	0.006	-0.642	0.510	0.6	0.0	0.0
1.3	-4.373	0.008	0.0	0.006	-0.664	0.528	1.3	0.0	0.0
4.3	-4.373	0.008	0.0	0.006	-0.664	0.528	4.3	0.0	0.0
10.3	-4.522	0.006	-0.310E-05	0.004	-0.687	0.552	10.3	0.0	0.0
22.3	-4.774	0.011	0.310E-05	0.008	-0.726	0.574	22.3	-5.509	1.348
30.3	-4.889	-0.002	-0.115E-04	-0.002	-0.743	0.611	30.3	0.0	0.0
46.3	-5.024	0.010	0.538E-05	0.007	-0.764	0.606	46.3	-5.270	1.866
71.3	-5.172	0.004	-0.174E-05	0.003	-0.786	0.635	71.3	0.0	0.0
103.3	-5.473	0.008	0.989E-06	0.006	-0.832	0.665	103.3	-6.014	2.014
122.3	-5.475	0.012	0.131E-05	0.008	-0.832	0.660	122.3	-5.884	2.087
142.3	-5.524	0.011	-0.310E-06	0.008	-0.840	0.667	142.3	0.0	0.0
166.3	-5.873	0.007	-0.103E-05	0.005	-0.893	0.717	166.3	0.0	0.0
191.8	-5.671	0.002	-0.146E-05	0.001	-0.862	0.701	191.8	0.0	0.0
214.8	-5.671	0.002	0.0	0.001	-0.862	0.701	214.8	0.0	0.0
240.3	-5.673	0.007	0.146E-05	0.005	-0.863	0.692	240.3	-5.836	2.381
286.3	-5.677	0.019	0.175E-05	0.013	-0.863	0.673	286.3	-5.756	2.457
310.3	-5.675	0.012	-0.207E-05	0.008	-0.863	0.684	310.3	0.0	0.0
334.3	-5.727	0.018	0.181E-05	0.013	-0.871	0.680	334.3	-5.743	2.524
360.3	-5.774	0.010	-0.215E-05	0.007	-0.878	0.700	360.3	0.0	0.0
382.3	-5.775	0.013	0.845E-06	0.009	-0.878	0.695	382.3	-6.073	2.582
409.3	-5.773	0.007	-0.161E-05	0.005	-0.878	0.706	409.3	0.0	0.0
432.3	-5.877	0.019	0.377E-05	0.013	-0.894	0.698	432.3	-5.423	2.636
454.3	-5.777	0.019	0.0	0.013	-0.879	0.685	454.3	0.0	0.0

LOAD INCREMENT # 2 S.D.= 98 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (MM/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	0.035	0.115	0.794E-01	0.079	0.005	0.199	0.0	-1.100	-2.000
0.1	0.025	0.142	0.155E-02	0.098	0.004	0.243	0.1	-2.809	-0.886
0.3	0.025	0.142	0.0	0.098	0.004	0.243	0.3	0.0	0.0
0.6	-0.024	0.139	-0.993E-04	0.096	-0.004	0.231	0.6	0.0	0.0
0.8	-0.055	0.140	0.496E-04	0.097	-0.008	0.230	0.8	-4.304	-0.097
1.3	-0.095	0.140	0.0	0.097	-0.015	0.225	1.3	0.0	0.0
2.3	-0.224	0.138	-0.186E-04	0.095	-0.034	0.205	2.3	-5.509	1.348
3.3	-0.175	0.140	0.186E-04	0.097	-0.027	0.215	3.3	-4.730	0.519
5.3	-0.073	0.136	-0.155E-04	0.094	-0.011	0.220	5.3	-5.270	1.866
7.3	-0.023	0.136	0.0	0.094	-0.004	0.227	7.3	0.0	0.0
11.3	0.027	0.137	0.155E-05	0.094	0.004	0.234	11.3	-5.809	1.053
23.8	0.123	0.145	0.447E-05	0.100	0.019	0.260	23.8	-5.349	1.377

AYLIN EQUATION NUMBER 1

Y = -1.760999 -1.833156 X -.6711310 X**2 + .9098876E-01 X**3

T-VALUES ARE : 1.0352 1.2370 0.1436
RSQUARE = 0.5522 STD. ERR. OF EST. = 1.986880

LOAD INCREMENT # 3 S.D.= 196 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (MM/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	0.108	0.160	0.110E+00	0.110	0.016	0.283	23.8	-0.958	-2.000
0.1	0.055	0.167	0.414E-03	0.115	0.008	0.289	23.9	-3.383	-0.886
0.4	0.047	0.188	0.596E-03	0.130	0.007	0.324	24.2	-3.225	-0.420
0.6	-0.003	0.188	0.0	0.130	-0.001	0.318	24.4	0.0	0.0
0.9	-0.056	0.195	0.174E-03	0.134	-0.009	0.322	24.7	-3.760	-0.056
1.4	-0.060	0.205	0.136E-03	0.141	-0.009	0.338	25.2	-3.885	0.140
2.4	-0.084	0.215	0.745E-04	0.149	-0.013	0.353	26.2	-4.128	0.377
3.4	-0.065	0.219	0.248E-04	0.151	-0.010	0.362	27.2	-4.605	0.529
5.4	-0.071	0.233	0.465E-04	0.160	-0.011	0.384	29.2	-4.332	0.731
7.4	-0.075	0.242	0.342E-04	0.167	-0.011	0.400	31.2	-4.466	0.868
11.4	-0.084	0.266	0.403E-04	0.183	-0.013	0.439	35.2	-4.394	1.056
23.4	-0.099	0.305	0.228E-04	0.211	-0.015	0.504	47.2	-4.843	1.369

AYLIN EQUATION NUMBER 2

Y = -3.301862 -.8215630 X -.1279252 X**2 - .1333860 X**3

T-VALUES ARE : 0.8007 0.2316 0.2852
RSQUARE = 0.4539 STD. ERR. OF EST. = 1.289029

LOAD INCREMENT # 4 S.D.= 294 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (MM/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	-0.118	0.328	0.226E+00	0.226	-0.018	0.539	47.2	-0.646	-2.000
0.1	-0.175	0.345	0.169E-02	0.238	-0.027	0.561	47.3	-2.773	-1.097
0.4	-0.235	0.373	0.566E-03	0.257	-0.036	0.601	47.6	-3.247	-0.377
0.9	-0.293	0.394	0.286E-03	0.272	-0.045	0.628	48.1	-3.544	-0.036
1.4	-0.299	0.408	0.199E-03	0.281	-0.046	0.652	48.6	-3.702	0.152
2.4	-0.311	0.439	0.211E-03	0.303	-0.048	0.702	49.6	-3.675	0.384
3.4	-0.268	0.458	0.131E-03	0.316	-0.041	0.740	50.6	-3.884	0.534
5.4	-0.285	0.501	0.149E-03	0.345	-0.044	0.811	52.6	-3.826	0.734
7.4	-0.346	0.529	0.995E-04	0.365	-0.053	0.852	54.6	-4.002	0.870
12.4	-0.417	0.583	0.747E-04	0.403	-0.064	0.934	59.6	-4.127	1.094
23.4	-0.485	0.628	0.288E-04	0.434	-0.074	1.004	70.6	-4.540	1.370

AVLIN EQUATION NUMBER 3

Y = -3.553347 -.4077806 X + .8500344E-01 X**2 -.2178743 X**3

T-VALUES ARE : 6.2648 2.4260 7.3686
RSQUARE = 0.9955 STD. ERR. OF EST. = .8331362E-01

LOAD INCREMENT # 5 S.D.= 392 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (MM/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	-0.469	0.640	0.442E+00	0.442	-0.072	1.023	70.6	-0.355	-2.000
0.1	-0.521	0.645	0.534E-03	0.445	-0.080	1.026	70.7	-3.273	-1.097
0.3	-0.576	0.657	0.324E-03	0.453	-0.088	1.039	70.9	-3.490	-0.481
0.6	-0.577	0.660	0.996E-04	0.456	-0.088	1.045	71.2	-4.002	-0.237
0.8	-0.599	0.665	0.124E-03	0.459	-0.092	1.050	71.4	-3.906	-0.081
1.3	-0.579	0.665	0.0	0.459	-0.104	1.040	71.9	-3.675	0.384
2.3	-0.703	0.675	0.685E-04	0.466	-0.107	1.053	72.9	-4.164	0.367
3.3	-0.707	0.686	0.748E-04	0.473	-0.108	1.071	73.9	-4.126	0.522
5.3	-0.690	0.692	0.217E-04	0.478	-0.105	1.084	75.9	-4.663	0.727
7.3	-0.714	0.702	0.343E-04	0.485	-0.109	1.098	77.9	-4.465	0.865
24.3	-0.818	0.764	0.253E-04	0.528	-0.125	1.190	94.9	-4.597	1.386

AVLIN EQUATION NUMBER 4

Y = -3.995064 -.3612718 X + .2145858 X**2 -.2497985 X**3

T-VALUES ARE : 1.7140 1.7956 2.6103
RSQUARE = 0.9596 STD. ERR. OF EST. = .2869963

LOAD INCREMENT # 6 S.D.= 490 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (MM/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	-0.839	0.768	0.530E+00	0.530	-0.128	1.194	94.9	-0.275	-2.000
0.1	-0.840	0.770	0.139E-03	0.532	-0.128	1.197	95.0	-3.856	-1.000
0.4	-0.845	0.781	0.324E-03	0.540	-0.129	1.216	95.3	-3.490	-0.456
0.6	-0.897	0.787	0.150E-03	0.543	-0.137	1.219	95.5	-3.825	-0.222
0.9	-0.947	0.789	0.501E-04	0.545	-0.145	1.216	95.8	-4.300	-0.071
1.1	-0.970	0.795	0.175E-03	0.549	-0.148	1.224	96.0	-3.758	0.041
1.6	-1.051	0.798	0.374E-04	0.551	-0.161	1.218	96.5	-4.427	0.204
2.6	-1.005	0.808	0.748E-04	0.558	-0.154	1.242	97.5	-4.126	0.415
4.6	-0.959	0.818	0.343E-04	0.565	-0.147	1.265	99.5	-4.465	0.663
6.6	-0.965	0.834	0.530E-04	0.576	-0.148	1.290	101.5	-4.276	0.820
10.1	-0.972	0.852	0.356E-04	0.588	-0.149	1.320	105.0	-4.449	1.004
23.1	-1.144	0.807	0.297E-04	0.627	-0.175	1.393	118.0	-4.527	1.364

AVLIN EQUATION NUMBER 5

Y = -4.112198 -.1980265 X + .2486756 X**2 -.2957316 X**3

T-VALUES ARE 0.7935 1.7694 2.5449
RSQUARE = 0.9434 STD. ERR. OF EST. = .3245508

LOAD INCREMENT # 7 S.D.= 588 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (MM/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	-1.158	0.918	0.634E+00	0.634	-0.177	1.409	118.0	-0.198	-2.000
0.1	-1.160	0.924	0.625E-03	0.639	-0.177	1.419	118.1	-3.204	-1.097
0.3	-1.162	0.928	0.147E-03	0.641	-0.178	1.425	118.3	-3.833	-0.802
0.5	-1.213	0.931	0.988E-04	0.644	-0.186	1.425	118.5	-4.001	-0.301
0.8	-1.266	0.938	0.199E-03	0.649	-0.194	1.430	118.8	-3.701	-0.125
1.3	-1.290	0.949	0.150E-03	0.656	-0.197	1.446	119.3	-3.824	0.097
2.3	-1.325	0.963	0.935E-04	0.665	-0.203	1.464	120.3	-4.029	0.352
7.3	-1.345	1.013	0.688E-04	0.700	-0.206	1.547	125.3	-4.158	0.860
11.8	-1.325	1.039	0.402E-04	0.718	-0.203	1.594	129.8	-4.395	1.070
24.8	-1.431	1.106	0.351E-04	0.765	-0.219	1.694	142.9	-4.454	1.396

AVLIN EQUATION NUMBER 6

Y = -3.954831 -.9347880E-01 X + .2134890 X**2 -.3365144 X**3

T-VALUES ARE : 0.7407 3.0556 5.8384
RSQUARE = 0.9891 STD. ERR. OF EST. = .1588062

LOAD INCREMENT # 8 S.D.= 687 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (MM/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	-1.464	1.113	0.769E+00	0.769	-0.224	1.702	142.9	-0.114	-2.000
0.1	-1.494	1.114	0.892E-04	0.770	-0.229	1.699	143.0	-4.049	-1.097
0.3	-1.515	1.116	0.110E-03	0.772	-0.232	1.701	143.2	-3.958	-0.602
0.4	-1.517	1.122	0.220E-03	0.776	-0.232	1.710	143.4	-3.657	-0.377
0.7	-1.572	1.134	0.350E-03	0.784	-0.240	1.725	143.6	-3.456	-0.174
1.2	-1.623	1.136	0.250E-04	0.786	-0.248	1.722	144.1	-4.602	0.068
1.7	-1.624	1.139	0.375E-04	0.787	-0.248	1.726	144.6	-4.426	0.223
2.7	-1.629	1.152	0.938E-04	0.797	-0.249	1.748	145.6	-4.028	0.427
7.7	-1.650	1.206	0.750E-04	0.834	-0.252	1.838	150.6	-4.125	0.885
12.2	-1.664	1.241	0.542E-04	0.859	-0.255	1.896	155.1	-4.266	1.085
23.7	-1.742	1.314	0.440E-04	0.909	-0.267	2.010	166.6	-4.356	1.374

AVLIN EQUATION NUMBER 7

Y = -4.129586 + .1596963 X + .2463485 X**2 -.4042735 X**3

T-VALUES ARE : 0.4617 1.2538 2.5090
RSQUARE = 0.9072 STD. ERR. OF EST. = .4529850

LOAD INCREMENT # 9 S.D.= 784 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (MM/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	-1.757	1.327	0.918E+00	0.918	-0.269	2.029	166.6	-0.037	-2.000
0.1	-1.789	1.330	0.358E-03	0.920	-0.274	2.031	166.7	-3.446	-1.097
0.3	-1.841	1.337	0.200E-03	0.925	-0.282	2.037	166.9	-3.899	-0.481
0.6	-1.845	1.346	0.250E-03	0.932	-0.282	2.052	167.2	-3.602	-0.237
1.1	-1.851	1.362	0.213E-03	0.942	-0.283	2.077	167.7	-3.672	0.033
1.6	-1.853	1.367	0.751E-04	0.946	-0.283	2.086	168.2	-4.124	0.199
2.6	-1.878	1.381	0.939E-04	0.956	-0.287	2.106	169.2	-4.027	0.412
4.6	-1.869	1.408	0.970E-04	0.975	-0.286	2.155	171.2	-4.013	0.661
7.6	-1.882	1.443	0.793E-04	0.999	-0.288	2.211	174.2	-4.101	0.880
11.6	-1.904	1.498	0.971E-04	1.038	-0.291	2.303	178.2	-4.013	1.064
24.9	-1.992	1.597	0.515E-04	1.106	-0.305	2.460	191.5	-4.289	1.395

AVLIN EQUATION NUMBER 8

Y = -3.920307 -.2659363E-01 X + .2604466 X**2 -.3396515 X**3

T-VALUES ARE : 0.1553 2.7954 4.3644
RSQUARE = 0.9750 STD ERR. OF EST. = .2254757

LOAD INCREMENT #10 S.D.= 882 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (MM/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	-2.006	1.808	0.111E+01	1.112	-0.307	2.474	191.5	0.046	-2.000
0.1	-2.009	1.812	0.628E-03	1.117	-0.307	2.485	191.5	-3.202	-1.097
0.3	-2.061	1.820	0.295E-03	1.122	-0.315	2.490	191.7	-3.530	-0.802
0.4	-2.115	1.828	0.332E-03	1.128	-0.324	2.498	191.8	-3.479	-0.377
0.8	-2.118	1.836	0.113E-03	1.133	-0.324	2.511	192.4	-3.948	-0.036
1.4	-2.124	1.851	0.213E-03	1.144	-0.325	2.536	192.9	-3.671	0.152
2.4	-2.129	1.865	0.940E-04	1.153	-0.326	2.559	193.9	-4.027	0.384
7.4	-2.168	1.764	0.138E-03	1.222	-0.332	2.723	198.9	-3.860	0.870
11.4	-2.188	1.815	0.894E-04	1.258	-0.335	2.808	202.9	-4.048	1.058
23.4	-2.240	1.948	0.774E-04	1.351	-0.343	3.029	214.9	-4.111	1.370

AVLIN EQUATION NUMBER 9

Y = -3.827833 -.8327949E-01 X + .2942041 X**2 -.3106521 X**3

T-VALUES ARE : 0.5589 3.3645 4.4303
RSQUARE = 0.9840 STD. ERR. OF EST. = .1922255

LOAD INCREMENT #11 S.D.= 980 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (MM/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	-2.162	1.954	0.136E+01	1.355	-0.331	3.049	214.8	0.132	-2.000
0.1	-2.165	1.961	0.718E-03	1.360	-0.331	3.061	214.9	-3.144	-1.097
0.3	-2.167	1.969	0.285E-03	1.365	-0.332	3.073	215.1	-3.530	-0.802
0.5	-2.171	1.977	0.226E-03	1.371	-0.332	3.087	215.4	-3.645	-0.301
0.8	-2.175	1.987	0.302E-03	1.378	-0.333	3.105	215.6	-3.520	-0.125
1.3	-2.230	2.001	0.188E-03	1.388	-0.341	3.121	216.1	-3.725	0.097
1.8	-2.233	2.007	0.880E-04	1.392	-0.342	3.131	216.6	-4.055	0.243
2.8	-2.243	2.033	0.182E-03	1.410	-0.343	3.175	217.6	-3.739	0.439
4.8	-2.209	2.076	0.148E-03	1.440	-0.338	3.251	219.6	-3.830	0.677
7.8	-2.232	2.133	0.134E-03	1.480	-0.342	3.347	222.6	-3.872	0.869
24.3	-2.134	2.396	0.111E-03	1.664	-0.327	3.810	239.1	-3.953	1.385

AVLIN EQUATION NUMBER 10

Y = -3.793068 -.5589550E-01 X + .3371367 X**2 -.3020164 X**3

T-VALUES ARE : 0.4272 4.5611 5.0721
RSQUARE = 0.9843 STD. ERR. OF EST. = .1771756

LOAD INCREMENT #12 S.D.= 1028 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (MM/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	0.182	2.406	0.167E+01	1.671	0.028	4.116	239.1	0.223	-2.000
0.1	0.382	2.406	0.0	1.671	0.058	4.141	239.2	-3.144	-1.097
0.4	0.680	2.410	0.929E-04	1.674	0.104	4.185	239.5	-4.032	-0.377
1.2	0.773	2.426	0.188E-03	1.687	0.118	4.228	240.3	-3.775	0.068
3.2	0.940	2.463	0.121E-03	1.711	0.143	4.309	242.3	-3.917	0.505
6.2	0.962	2.508	0.105E-03	1.743	0.147	4.389	245.3	-3.978	0.792
11.4	1.161	2.588	0.106E-03	1.798	0.177	4.550	250.6	-3.976	1.059
23.2	1.455	2.731	0.860E-04	1.899	0.222	4.834	262.3	-4.066	1.365
59.7	2.247	3.009	0.534E-04	2.094	0.343	5.409	298.8	-4.273	1.776
71.7	2.119	3.080	0.417E-04	2.144	0.323	5.516	310.8	-4.380	1.856
97.7	2.465	3.219	0.378E-04	2.242	0.376	5.799	336.8	-4.423	1.990
120.2	2.734	3.299	0.251E-04	2.299	0.417	5.971	359.3	-4.601	2.080
143.2	3.004	3.376	0.234E-04	2.353	0.458	6.137	382.3	-4.630	2.156
167.7	3.221	3.461	0.246E-04	2.413	0.491	6.311	406.8	-4.609	2.225
191.2	3.341	3.538	0.230E-04	2.467	0.509	6.458	430.3	-4.639	2.281
217.7	3.154	3.631	0.248E-04	2.533	0.481	6.597	456.8	-4.603	2.338
240.7	3.151	3.716	0.260E-04	2.593	0.480	6.743	479.8	-4.585	2.381
263.7	3.230	3.772	0.172E-04	2.632	0.492	6.849	502.8	-4.766	2.421
287.7	3.232	3.817	0.133E-04	2.664	0.493	6.928	526.8	-4.878	2.459
311.7	3.209	3.876	0.175E-04	2.706	0.489	7.028	550.8	-4.757	2.494
335.7	3.295	3.911	0.104E-04	2.731	0.502	7.099	574.8	-4.985	2.526
359.2	3.475	3.962	0.154E-04	2.767	0.529	7.211	598.3	-4.811	2.555
385.7	3.651	4.024	0.164E-04	2.811	0.556	7.339	624.8	-4.786	2.586
410.7	4.030	4.078	0.153E-04	2.849	0.614	7.479	649.8	-4.815	2.614
437.7	4.319	4.106	0.758E-05	2.869	0.658	7.565	676.8	-5.122	2.641
461.7	4.502	4.151	0.133E-04	2.901	0.700	7.678	700.8	-4.877	2.664
485.7	4.298	4.161	0.283E-05	2.908	0.654	7.658	724.8	-5.534	2.686
508.7	4.478	4.213	0.152E-04	2.945	0.682	7.769	748.8	-4.819	2.707
533.7	4.361	4.256	0.128E-04	2.975	0.664	7.830	772.8	-4.894	2.727
559.2	4.447	4.291	0.977E-05	3.000	0.677	7.901	798.3	-5.010	2.748
584.2	4.833	4.328	0.105E-04	3.026	0.736	8.013	823.3	-4.980	2.767
605.7	4.817	4.368	0.134E-04	3.055	0.733	8.082	844.8	-4.874	2.782
632.7	5.093	4.429	0.161E-04	3.098	0.775	8.222	871.8	-4.793	2.801

AVLIN EQUATION NUMBER 11

Y = -4.002481 -.4761460 X + .4588840 X**2 -.1547353 X**3

T-VALUES ARE : 5.9735 11.2593 8.3183
RSQUARE = 0.9853 STD. ERR OF EST. = .2125106
PLOT 1, 1670 UNPLOTTABLE POINTS

GEOTECHNICAL LABORATORIES
DEPARTMENT OF CIVIL ENGINEERING
UNIVERSITY OF MANITOBA

CONSTANT CELL PRESSURE MULTI-STAGE TRIAXIAL CREEP TEST

MST10 – σ_3 =70 kPa

LOAD INCREMENT # 1 S.D.= 0 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	-1.020	0.0	0.0	0.0	-0.148	0.122	0.0	0.0	0.0
0.5	-1.220	0.0	0.0	0.0	-0.178	0.146	0.5	0.0	0.0
2.3	-1.323	0.008	0.308E-04	0.005	-0.194	0.146	2.3	-4.512	0.352
6.3	-1.222	0.006	-0.300E-05	0.004	-0.179	0.136	6.3	0.0	0.0
23.8	-1.422	0.006	0.0	0.004	-0.208	0.160	23.8	0.0	0.0
48.8	-1.522	0.006	0.0	0.004	-0.223	0.172	48.8	0.0	0.0
70.8	-1.573	0.007	0.274E-06	0.005	-0.230	0.176	70.8	-6.563	1.850
95.3	-1.671	0.002	-0.147E-05	0.001	-0.245	0.197	95.3	0.0	0.0
118.7	-1.821	0.003	0.257E-06	0.002	-0.267	0.213	118.7	-6.591	2.074
142.7	-1.821	0.003	0.0	0.002	-0.267	0.213	142.7	0.0	0.0
166.7	-1.872	0.006	0.986E-06	0.004	-0.274	0.214	166.7	-6.002	2.222
191.7	-1.921	0.004	-0.718E-06	0.002	-0.281	0.224	181.7	0.0	0.0
221.2	-2.172	0.006	0.808E-06	0.004	-0.318	0.250	221.2	-6.216	2.345
238.2	-2.174	0.009	0.106E-05	0.006	-0.318	0.245	238.2	-5.977	2.377
262.0	-2.123	0.007	-0.501E-06	0.005	-0.311	0.242	262.0	0.0	0.0
286.0	-2.223	0.007	0.0	0.005	-0.326	0.254	286.0	0.0	0.0
310.0	-2.325	0.013	0.150E-05	0.008	-0.341	0.258	310.0	-5.825	2.491
334.0	-2.324	0.009	-0.998E-06	0.006	-0.340	0.263	334.0	0.0	0.0
359.5	-2.225	0.012	0.706E-06	0.008	-0.328	0.247	359.5	-6.151	2.556
388.0	-2.324	0.011	-0.211E-06	0.007	-0.341	0.260	388.0	0.0	0.0
407.0	-2.376	0.016	0.189E-05	0.011	-0.348	0.258	407.0	-5.723	2.610

LOAD INCREMENT # 2 S.D.= 16 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	-0.043	-0.018	-0.127E-01	-0.013	-0.006	0.036	0.0	0.0	0.0
0.5	-0.082	-0.020	-0.117E-04	-0.013	-0.014	0.044	0.5	0.0	0.0
1.0	-0.143	-0.019	0.114E-04	-0.013	-0.021	0.048	1.0	-4.941	0.0
2.0	-0.144	-0.016	0.181E-04	-0.011	-0.021	0.044	2.0	-4.742	0.301
4.0	-0.042	-0.022	-0.176E-04	-0.014	-0.006	0.040	4.0	0.0	0.0
17.0	-0.041	-0.024	-0.954E-06	-0.016	-0.006	0.043	17.0	0.0	0.0
23.0	0.059	-0.023	0.954E-06	-0.015	0.009	0.030	23.0	-6.021	1.362
31.0	0.059	-0.023	0.0	-0.015	0.009	0.030	31.0	0.0	0.0
46.0	0.057	-0.019	0.159E-05	-0.013	0.008	0.024	46.0	-5.799	1.663
71.5	0.057	-0.019	0.0	-0.013	0.008	0.024	71.5	0.0	0.0
95.0	0.057	-0.017	0.527E-06	-0.011	0.008	0.021	95.0	-6.276	1.978
121.0	0.057	-0.017	0.0	-0.011	0.008	0.021	121.0	0.0	0.0
146.0	0.055	-0.014	0.954E-06	-0.009	0.008	0.018	146.0	-6.021	2.164
173.0	0.005	-0.014	0.0	-0.009	0.001	0.022	173.0	-5.877	2.377
202.0	0.057	-0.018	-0.102E-05	-0.012	0.008	0.023	202.0	0.0	0.0
226.5	0.057	-0.019	-0.272E-06	-0.013	0.008	0.024	226.5	0.0	0.0

LOAD INCREMENT # 3 S.D.= 33 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	0.040	-0.026	-0.169E-01	-0.017	0.006	0.037	226.5	0.0	0.0
0.5	-0.040	-0.026	0.0	-0.017	-0.006	0.046	227.0	0.0	0.0
1.3	-0.144	-0.016	0.877E-04	-0.010	-0.021	0.042	227.7	-4.057	0.097
2.3	-0.146	-0.011	0.296E-04	-0.007	-0.021	0.035	228.7	-4.529	0.352
4.3	-0.095	-0.013	-0.572E-05	-0.008	-0.014	0.032	230.7	0.0	0.0
7.3	-0.047	-0.008	0.118E-04	-0.005	-0.007	0.018	233.7	-4.930	0.860
24.0	0.003	-0.008	-0.342E-06	-0.006	0.000	0.013	250.5	-6.021	1.362
47.5	0.248	0.004	0.354E-05	0.003	0.036	0.037	274.0	-5.451	1.677

LOAD INCREMENT # 4 S.D.= 33 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
55.5	-0.232	-0.580	-0.668E-04	-0.372	-0.034	0.938	329.5	0.0	0.0
73.5	-0.384	-0.425	0.497E-04	-0.282	-0.056	0.737	347.5	-4.304	1.866
120.0	-1.222	0.185	0.871E-04	0.123	-0.180	0.165	394.0	-4.060	2.079
167.0	0.178	0.185	0.0	0.123	0.026	0.323	441.0	-4.529	0.352
191.0	0.179	0.183	-0.500E-06	0.122	0.026	0.320	465.0	0.0	0.0
215.0	0.179	0.181	-0.500E-06	0.121	0.026	0.317	489.0	-4.930	0.860
264.0	0.229	0.183	0.245E-06	0.122	0.033	0.326	538.0	-6.611	2.422
287.0	0.378	0.185	0.522E-06	0.123	0.055	0.347	561.0	-6.283	2.458
311.0	0.477	0.188	0.748E-06	0.125	0.070	0.363	585.0	-6.126	2.483
335.0	0.577	0.188	0.0	0.125	0.085	0.375	609.0	0.0	0.0
359.0	0.675	0.191	0.100E-05	0.127	0.099	0.393	633.0	-6.000	2.555
383.0	0.730	0.179	-0.350E-05	0.119	0.107	0.379	657.0	0.0	0.0
438.0	1.176	0.189	0.118E-05	0.125	0.172	0.448	713.0	-5.929	2.642
503.0	1.179	0.181	-0.749E-06	0.121	0.173	0.437	777.0	-5.977	2.377

LOAD INCREMENT # 5 S.D.= 49 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	1.201	0.176	0.117E+00	0.117	0.176	0.431	777.0	-0.931	-2.000
0.3	1.231	0.177	0.251E-04	0.118	0.180	0.436	777.2	-4.600	-0.602
0.8	1.203	0.172	-0.720E-04	0.114	0.176	0.424	777.7	-4.060	2.079
2.3	1.203	0.172	0.0	0.114	0.176	0.424	779.2	-4.529	0.352
4.8	1.203	0.172	0.0	0.114	0.176	0.424	781.7	0.0	0.0
23.0	1.282	0.175	0.131E-05	0.117	0.188	0.439	800.0	-5.881	1.362
47.0	1.381	0.176	0.249E-06	0.117	0.202	0.452	824.0	-6.604	1.672
69.0	1.480	0.179	0.819E-06	0.119	0.217	0.469	846.0	-6.087	1.839
96.5	1.580	0.178	0.0	0.119	0.232	0.481	873.5	-5.126	2.493
117.0	1.579	0.183	0.146E-05	0.122	0.231	0.488	894.0	-5.837	2.068

LOAD INCREMENT # 6 S.D.= 85 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	1.578	0.181	0.120E+00	0.120	0.231	0.484	894.0	-0.919	-2.000
0.3	1.580	0.179	-0.500E-04	0.119	0.232	0.481	894.2	-4.600	-0.802
0.8	1.481	0.178	-0.119E-04	0.118	0.217	0.468	894.7	-4.060	2.079
2.3	1.579	0.182	0.160E-04	0.121	0.231	0.485	896.2	-4.787	0.352
9.3	1.579	0.181	-0.853E-06	0.120	0.231	0.484	903.2	0.0	0.0
24.0	1.579	0.181	0.0	0.120	0.231	0.484	918.0	-5.881	1.362
48.0	1.626	0.191	0.275E-05	0.127	0.238	0.506	942.0	-6.561	1.681
73.5	1.675	0.194	0.707E-06	0.129	0.245	0.516	967.5	-6.151	1.866
101.0	1.770	0.204	0.261E-05	0.136	0.259	0.545	995.0	-5.583	2.004
120.0	1.870	0.204	0.0	0.136	0.274	0.557	1014.0	-6.837	2.068
144.0	1.869	0.208	0.997E-06	0.138	0.274	0.562	1038.0	-6.001	2.158

LOAD INCREMENT # 7 S.D.= 82 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	1.871	0.204	0.136E+00	0.136	0.274	0.556	1038.0	-0.868	-2.000
0.5	1.871	0.203	-0.122E-04	0.135	0.274	0.554	1038.5	-4.600	-0.602
1.0	1.870	0.206	0.359E-04	0.137	0.274	0.559	1039.0	-4.445	0.0
2.5	1.867	0.214	0.360E-04	0.142	0.274	0.571	1040.5	-4.444	0.398
4.5	1.870	0.205	-0.300E-04	0.136	0.274	0.557	1042.5	0.0	0.0
7.5	1.870	0.205	0.0	0.136	0.274	0.557	1045.5	-5.881	1.362
23.5	1.964	0.221	0.673E-05	0.147	0.288	0.595	1061.5	-5.172	1.371
47.5	2.062	0.225	0.125E-05	0.150	0.302	0.614	1085.5	-5.903	1.677
71.5	2.058	0.236	0.299E-05	0.157	0.301	0.631	1109.5	-5.524	1.854
97.5	2.157	0.239	0.893E-06	0.159	0.316	0.647	1135.5	-6.159	1.989
123.5	2.253	0.248	0.230E-05	0.165	0.330	0.673	1161.5	-5.638	2.092
144.0	2.301	0.253	0.176E-05	0.168	0.337	0.688	1182.0	-5.755	2.158

LOAD INCREMENT # 8 S.D.= 86 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	2.300	0.257	0.171E+00	0.171	0.337	0.693	1182.0	-0.768	-2.000
0.5	2.251	0.255	-0.245E-04	0.169	0.330	0.684	1182.5	-4.600	-0.802
1.0	2.249	0.258	0.480E-04	0.172	0.330	0.690	1183.0	-4.319	0.0
2.0	2.249	0.260	0.120E-04	0.173	0.329	0.693	1184.0	-4.821	0.301
4.5	2.289	0.260	0.0	0.173	0.337	0.693	1186.5	0.0	0.0
7.0	2.248	0.261	0.239E-05	0.174	0.329	0.694	1189.0	-5.622	0.845
23.0	2.342	0.277	0.675E-05	0.184	0.343	0.732	1205.0	-6.171	1.362
74.0	2.528	0.312	0.458E-05	0.208	0.370	0.811	1256.0	-5.339	1.869
121.0	2.624	0.324	0.188E-05	0.216	0.384	0.842	1303.0	-5.780	2.083
144.5	2.720	0.334	0.281E-05	0.222	0.398	0.870	1326.5	-5.551	2.160
171.5	2.814	0.348	0.377E-05	0.232	0.412	0.906	1353.5	-5.423	2.234
218.0	3.004	0.375	0.374E-05	0.250	0.440	0.971	1400.0	-5.427	2.338
243.5	3.050	0.384	0.238E-05	0.256	0.447	0.991	1425.5	-5.628	2.386
270.0	3.096	0.394	0.249E-05	0.262	0.453	1.013	1452.0	-5.804	2.431
289.5	3.291	0.407	0.430E-05	0.271	0.462	1.057	1471.5	-5.366	2.462
312.5	3.338	0.416	0.261E-05	0.277	0.469	1.077	1494.5	-5.584	2.495

LOAD INCREMENT # 9 S.D.= 114 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	3.337	0.418	0.278E+00	0.278	0.489	1.081	1494.5	-0.555	-2.000
0.5	3.287	0.418	0.0	0.278	0.481	1.075	1495.0	-4.800	-0.602
1.0	3.285	0.423	0.598E-04	0.281	0.481	1.082	1495.5	-4.223	0.0
2.0	3.302	0.430	0.481E-04	0.286	0.483	1.096	1496.5	-4.318	0.301
4.0	3.381	0.434	0.150E-04	0.289	0.495	1.112	1498.5	-4.824	0.602
6.5	3.379	0.439	0.120E-04	0.292	0.495	1.118	1501.0	-4.921	0.813
23.0	3.365	0.476	0.145E-04	0.316	0.493	1.177	1517.5	-4.837	1.362
47.0	3.452	0.507	0.900E-05	0.338	0.505	1.240	1541.5	-5.046	1.672
71.0	3.546	0.524	0.475E-05	0.348	0.519	1.279	1565.5	-5.323	1.851
95.0	3.585	0.551	0.750E-05	0.367	0.525	1.328	1589.5	-5.125	1.978
128.5	3.708	0.569	0.381E-05	0.379	0.543	1.372	1621.0	-5.419	2.102
145.0	3.723	0.583	0.487E-05	0.388	0.545	1.396	1839.5	-5.312	2.161
167.0	3.833	0.608	0.764E-05	0.405	0.561	1.450	1661.5	-5.117	2.223
191.0	3.906	0.625	0.475E-05	0.416	0.572	1.487	1685.5	-5.323	2.281
215.0	3.998	0.646	0.576E-05	0.430	0.585	1.531	1709.5	-5.240	2.332
239.0	4.043	0.659	0.375E-05	0.439	0.592	1.558	1733.5	-5.426	2.378
263.0	4.137	0.675	0.426E-05	0.449	0.605	1.595	1757.5	-5.371	2.420
280.0	4.279	0.696	0.534E-05	0.464	0.626	1.647	1784.5	-5.272	2.452
319.0	4.322	0.713	0.394E-05	0.475	0.632	1.680	1813.5	-5.405	2.504
335.0	4.368	0.723	0.413E-05	0.482	0.639	1.702	1829.5	-5.384	2.525
359.0	4.462	0.738	0.401E-05	0.492	0.653	1.737	1853.5	-5.397	2.555
383.0	4.486	0.755	0.476E-05	0.503	0.656	1.768	1877.5	-5.322	2.583
407.0	4.551	0.767	0.350E-05	0.511	0.666	1.796	1901.5	-5.455	2.610
431.0	4.649	0.772	0.125E-05	0.514	0.680	1.815	1925.5	-5.902	2.634
456.5	4.738	0.800	0.731E-05	0.533	0.693	1.871	1951.0	-5.136	2.659
480.5	4.816	0.808	0.226E-05	0.538	0.704	1.894	1975.0	-5.646	2.682
503.0	4.832	0.817	0.267E-05	0.544	0.707	1.910	1997.5	-5.573	2.702

LOAD INCREMENT #10 S.D.= 130 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	4.881	0.818	0.546E+00	0.546	0.714	1.920	1997.5	-0.263	-2.000
0.5	4.829	0.823	0.492E-04	0.548	0.706	1.920	1998.0	-4.308	-0.301
2.5	4.876	0.832	0.300E-04	0.554	0.713	1.940	2000.0	-4.522	0.398
7.5	4.921	0.844	0.169E-04	0.563	0.720	1.966	2005.0	-4.773	0.875
23.5	4.906	0.882	0.158E-04	0.588	0.717	2.026	2021.0	-4.802	1.371
47.5	4.991	0.922	0.110E-04	0.615	0.730	2.101	2045.0	-4.957	1.677
71.5	5.080	0.949	0.752E-05	0.633	0.743	2.156	2069.0	-5.124	1.854
103.5	5.167	0.982	0.696E-05	0.655	0.755	2.221	2101.0	-5.157	2.015
121.0	5.259	1.004	0.826E-05	0.669	0.769	2.267	2118.5	-5.083	2.083
143.5	5.350	1.026	0.889E-05	0.684	0.782	2.315	2141.0	-5.175	2.157
167.5	5.439	1.053	0.753E-05	0.703	0.795	2.370	2165.0	-5.123	2.224
191.5	5.511	1.076	0.627E-05	0.718	0.805	2.415	2189.0	-5.203	2.282
215.5	5.552	1.098	0.628E-05	0.733	0.811	2.457	2213.0	-5.202	2.333
242.5	5.644	1.118	0.491E-05	0.746	0.825	2.501	2240.0	-5.309	2.385
265.5	5.703	1.147	0.838E-05	0.765	0.833	2.555	2263.0	-5.077	2.424
287.5	5.798	1.180	0.411E-05	0.774	0.847	2.588	2285.0	-5.386	2.459
312.5	5.894	1.170	0.285E-05	0.781	0.861	2.616	2310.0	-5.676	2.495
335.5	5.938	1.186	0.472E-05	0.792	0.858	2.648	2333.0	-5.326	2.526
359.5	5.982	1.201	0.402E-05	0.801	0.874	2.677	2357.0	-5.395	2.558
386.5	6.106	1.216	0.367E-05	0.811	0.892	2.715	2384.0	-5.447	2.587
433.0	6.268	1.237	0.311E-05	0.825	0.916	2.770	2430.5	-5.507	2.636
453.5	6.361	1.255	0.589E-05	0.838	0.929	2.810	2451.0	-5.230	2.657
472.5	6.386	1.268	0.476E-05	0.847	0.933	2.835	2470.0	-5.323	2.674
496.5	6.450	1.282	0.403E-05	0.856	0.942	2.857	2494.0	-5.395	2.696
520.5	6.543	1.300	0.477E-05	0.868	0.956	2.906	2518.0	-5.321	2.716
547.5	6.637	1.315	0.380E-05	0.878	0.969	2.942	2545.0	-5.420	2.738
594.5	6.729	1.336	0.295E-05	0.892	0.983	2.987	2592.0	-5.530	2.774
616.5	6.824	1.350	0.438E-05	0.902	0.998	3.022	2614.0	-5.357	2.790
640.5	6.818	1.363	0.377E-05	0.911	0.988	3.043	2638.0	-5.424	2.807
664.5	6.913	1.378	0.403E-05	0.920	1.009	3.078	2662.0	-5.395	2.822
688.5	6.958	1.390	0.327E-05	0.928	1.018	3.103	2686.0	-5.486	2.838
712.5	7.048	1.415	0.704E-05	0.945	1.029	3.155	2710.0	-5.152	2.853
782.0	7.184	1.428	0.148E-05	0.952	1.050	3.190	2759.5	-5.834	2.882
784.5	7.189	1.439	0.403E-05	0.961	1.050	3.212	2782.0	-5.395	2.895
808.5	7.333	1.453	0.403E-05	0.971	1.070	3.252	2806.0	-5.395	2.908
832.5	7.327	1.471	0.478E-05	0.982	1.070	3.280	2830.0	-5.321	2.920
856.5	7.372	1.482	0.328E-05	0.990	1.076	3.304	2854.0	-5.485	2.933
880.5	7.370	1.489	0.178E-05	0.995	1.076	3.314	2878.0	-5.754	2.945
928.5	7.384	1.503	0.201E-05	1.004	1.075	3.337	2926.0	-5.686	2.968
952.5	7.463	1.507	0.101E-05	1.007	1.089	3.355	2950.0	-5.996	2.978
976.5	7.860	1.514	0.201E-05	1.011	1.118	3.390	2974.0	-5.698	2.990
1000.5	7.754	1.528	0.428E-05	1.022	1.131	3.426	2998.0	-5.388	3.000
1024.5	7.769	1.543	0.378E-05	1.031	1.134	3.450	3022.0	-5.423	3.011
1048.5	7.846	1.550	0.202E-05	1.036	1.145	3.471	3046.0	-5.686	3.021
1081.5	7.988	1.570	0.403E-05	1.049	1.166	3.521	3079.0	-5.395	3.034
1120.5	8.129	1.593	0.403E-05	1.065	1.186	3.576	3118.0	-5.395	3.049
1144.5	8.125	1.602	0.252E-05	1.071	1.185	3.590	3142.0	-5.599	3.059
1168.5	8.220	1.615	0.378E-05	1.080	1.199	3.624	3166.0	-5.423	3.068
1192.5	8.215	1.629	0.378E-05	1.089	1.198	3.646	3190.0	-5.422	3.076
1216.5	8.261	1.638	0.252E-05	1.095	1.205	3.666	3214.0	-5.598	3.085
1263.0	8.404	1.656	0.260E-05	1.107	1.226	3.712	3260.5	-5.585	3.101
1285.5	8.500	1.668	0.350E-05	1.115	1.240	3.743	3283.0	-5.466	3.109
1309.5	8.545	1.680	0.353E-05	1.123	1.246	3.769	3307.0	-5.453	3.117
1333.5	8.592	1.686	0.177E-05	1.128	1.253	3.785	3331.0	-5.753	3.125
1357.5	8.638	1.695	0.252E-05	1.134	1.260	3.805	3355.0	-5.598	3.133
1389.5	8.685	1.704	0.188E-05	1.140	1.267	3.826	3387.0	-5.724	3.143
1431.0	8.778	1.722	0.292E-05	1.152	1.280	3.866	3428.5	-5.636	3.156
1453.5	8.824	1.733	0.323E-05	1.159	1.287	3.890	3451.0	-5.491	3.162
1477.5	8.870	1.743	0.277E-05	1.166	1.308	3.823	3476.0	-5.557	3.170
1501.5	9.066	1.754	0.303E-05	1.173	1.322	3.962	3499.0	-5.519	3.177
1525.5	9.063	1.763	0.252E-05	1.179	1.321	3.967	3523.0	-5.599	3.183
1549.5	9.057	1.776	0.378E-05	1.186	1.320	3.988	3547.0	-5.422	3.190

LOAD INCREMENT #11 S.D.= 147 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	9.057	1.776	0.119E+01	1.188	1.320	3.988	3547.0	0.075	-2.000
0.5	9.057	1.776	0.0	1.188	1.320	3.988	3547.5	-4.308	-0.301
3.0	9.053	1.788	0.339E-04	1.186	1.320	4.008	3550.0	-4.470	0.477
8.0	9.149	1.789	0.111E-04	1.203	1.334	4.036	3555.0	-4.955	0.954
25.0	9.141	1.819	0.870E-05	1.217	1.333	4.068	3572.0	-5.060	1.398
47.0	9.230	1.847	0.853E-05	1.236	1.346	4.125	3594.0	-5.068	1.672
72.0	9.272	1.867	0.533E-05	1.249	1.352	4.163	3619.0	-5.273	1.857
96.5	9.315	1.885	0.494E-05	1.261	1.358	4.198	3643.5	-5.306	1.985
120.0	9.407	1.906	0.567E-05	1.274	1.371	4.241	3667.0	-5.246	2.079
147.0	9.497	1.930	0.628E-05	1.291	1.384	4.284	3694.0	-5.202	2.167
171.0	9.588	1.954	0.657E-05	1.307	1.397	4.343	3718.0	-5.182	2.233
194.0	9.630	1.975	0.632E-05	1.322	1.403	4.383	3741.0	-5.199	2.288
217.5	9.673	1.993	0.518E-05	1.334	1.410	4.418	3764.5	-5.287	2.337
240.0	9.768	2.010	0.512E-05	1.345	1.423	4.457	3787.0	-5.291	2.380
264.0	9.759	2.028	0.505E-05	1.358	1.422	4.488	3811.0	-5.298	2.422
288.0	9.854	2.042	0.379E-05	1.367	1.436	4.520	3835.0	-5.421	2.459
312.0	9.950	2.053	0.303E-05	1.374	1.450	4.549	3859.0	-5.518	2.494
336.5	9.944	2.068	0.421E-05	1.384	1.449	4.574	3883.5	-5.376	2.527
362.0	10.038	2.081	0.357E-05	1.393	1.462	4.607	3909.0	-5.448	2.559
385.0	10.084	2.094	0.389E-05	1.402	1.469	4.633	3932.0	-5.433	2.585
408.0	10.129	2.107	0.369E-05	1.410	1.476	4.659	3955.0	-5.433	2.611
432.0	10.173	2.120	0.340E-05	1.419	1.482	4.687	3979.0	-5.421	2.635
462.0	10.219	2.133	0.263E-05	1.428	1.489	4.713	4009.0	-5.548	2.666
480.0	10.316	2.138	0.202E-05	1.432	1.503	4.733	4027.0	-5.694	2.681
508.0	10.410	2.153	0.369E-05	1.442	1.516	4.770	4055.0	-5.433	2.708
530.0	10.407	2.163	0.303E-05	1.449	1.518	4.788	4077.0	-5.518	2.724
552.0	10.498	2.184	0.635E-05	1.462	1.529	4.831	4098.0	-5.187	2.742
576.0	10.593	2.197	0.379E-05	1.472	1.543	4.864	4123.0	-5.421	2.760
600.0	10.640	2.208	0.263E-05	1.478	1.548	4.885	4147.0	-5.597	2.778
624.5	10.587	2.213	0.174E-05	1.482	1.542	4.889	4171.5	-5.761	2.796
648.5	10.781	2.228	0.430E-05	1.492	1.570	4.937	4195.5	-5.367	2.812
674.0	10.779	2.233	0.143E-05	1.496	1.570	4.946	4221.0	-5.845	2.829
697.5	10.826	2.242	0.259E-05	1.502	1.576	4.966	4244.5	-5.587	2.844
720.5	10.874	2.248	0.158E-05	1.506	1.583	4.981	4267.5	-5.802	2.858

LOAD INCREMENT #12 S.D.= 163 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	10.872	2.253	0.151E+01	1.509	1.583	4.989	4267.5	0.179	-2.000
0.5	10.872	2.253	0.0	1.509	1.583	4.989	4268.0	-4.308	-0.301
4.5	10.869	2.260	0.121E-04	1.514	1.583	5.000	4272.0	-4.916	0.653
8.5	10.866	2.266	0.106E-04	1.518	1.582	5.010	4276.0	-4.973	0.929
23.5	10.959	2.284	0.809E-05	1.530	1.596	5.051	4291.0	-5.092	1.371
48.0	11.049	2.311	0.744E-05	1.548	1.609	5.106	4315.5	-5.129	1.681
72.0	11.142	2.329	0.507E-05	1.561	1.622	5.147	4339.5	-5.295	1.857
95.5	11.133	2.352	0.646E-05	1.576	1.621	5.183	4363.0	-5.189	1.980
128.5	11.275	2.373	0.423E-05	1.590	1.641	5.234	4396.0	-5.373	2.109
145.5	11.320	2.385	0.501E-05	1.598	1.648	5.260	4413.0	-5.300	2.163
168.0	11.313	2.402	0.513E-05	1.610	1.647	5.288	4435.5	-5.290	2.225
191.5	11.409	2.415	0.362E-05	1.618	1.661	5.320	4459.0	-5.441	2.282
215.5	11.503	2.428	0.380E-05	1.627	1.674	5.353	4483.0	-6.421	2.333
239.5	11.547	2.445	0.456E-05	1.638	1.680	5.385	4507.0	-5.341	2.379
263.5	11.641	2.461	0.456E-05	1.649	1.694	5.423	4531.0	-5.341	2.421
289.5	11.685	2.474	0.351E-05	1.659	1.700	5.451	4557.0	-5.454	2.462
313.5	11.679	2.490	0.431E-05	1.669	1.700	5.475	4581.0	-5.366	2.496
337.5	11.776	2.499	0.279E-05	1.676	1.713	5.503	4605.0	-5.555	2.528
359.5	11.772	2.509	0.304E-05	1.682	1.713	5.519	4627.0	-5.517	2.556
383.5	11.818	2.518	0.253E-05	1.688	1.720	5.540	4651.0	-5.597	2.584
407.5	11.863	2.532	0.380E-05	1.697	1.726	5.567	4675.0	-5.420	2.610
431.5	11.959	2.543	0.304E-05	1.705	1.740	5.598	4699.0	-5.517	2.636
457.5	11.955	2.552	0.234E-05	1.711	1.739	5.611	4725.0	-5.831	2.660
482.5	12.052	2.560	0.219E-05	1.716	1.753	5.636	4750.0	-5.659	2.683
503.5	12.097	2.572	0.405E-05	1.725	1.760	5.662	4771.0	-5.392	2.702
527.5	12.244	2.581	0.254E-05	1.731	1.781	5.694	4795.0	-5.596	2.722
551.5	12.239	2.592	0.305E-05	1.738	1.780	5.711	4819.0	-5.516	2.742
575.5	12.235	2.603	0.304E-05	1.746	1.780	5.729	4843.0	-5.517	2.760
599.5	13.810	3.180	0.163E-03	2.136	2.007	6.872	4867.0	-3.788	2.778
605.5	8.745	3.091	-0.101E-03	2.076	1.275	6.126	4873.0	-5.761	2.796
626.0	10.018	3.160	0.228E-04	2.123	1.459	6.392	4893.5	-4.639	2.797
650.0	10.010	3.180	0.560E-05	2.136	1.458	6.424	4917.5	-5.252	2.813
671.5	10.005	3.193	0.427E-05	2.146	1.458	6.446	4939.0	-5.370	2.827
695.5	10.000	3.206	0.357E-05	2.154	1.457	6.466	4963.0	-5.448	2.842
719.5	10.098	3.211	0.153E-05	2.158	1.471	6.487	4987.0	-5.817	2.857
743.5	10.098	3.212	0.254E-06	2.158	1.471	6.488	5011.0	-6.595	2.871
767.5	10.184	3.223	0.305E-05	2.166	1.485	6.518	5035.0	-5.515	2.885
839.0	10.290	3.231	0.108E-05	2.171	1.499	6.542	5086.0	-5.987	2.913
863.5	10.286	3.242	0.357E-05	2.179	1.498	6.560	5106.5	-5.447	2.924
887.5	10.384	3.244	0.748E-06	2.180	1.505	6.570	5131.0	-6.126	2.938
911.5	10.383	3.247	0.764E-06	2.182	1.512	6.580	5155.0	-6.117	2.948
935.5	10.482	3.251	0.102E-05	2.185	1.512	6.586	5179.0	-5.981	2.960
986.5	10.578	3.253	0.510E-06	2.186	1.527	6.601	5203.0	-6.292	2.971
1010.5	10.578	3.262	0.132E-05	2.193	1.540	6.629	5254.0	-5.880	2.994
1031.5	10.675	3.262	0.0	2.193	1.540	6.628	5278.0	-5.395	3.034
1055.5	10.674	3.271	0.262E-05	2.198	1.554	6.654	5298.0	-5.582	3.013
1079.5	10.873	3.272	0.510E-06	2.198	1.554	6.657	5323.0	-6.282	3.023
1103.5	10.772	3.276	0.764E-06	2.201	1.554	6.661	5347.0	-6.117	3.033
1138.0	10.820	3.278	0.767E-06	2.203	1.569	6.677	5371.0	-6.115	3.043
1175.5	10.889	3.284	0.121E-05	2.207	1.575	6.693	5406.5	-5.918	3.057
1201.0	10.958	3.287	0.502E-06	2.209	1.582	6.704	5443.0	-6.289	3.070
1223.5	10.966	3.288	0.238E-06	2.210	1.597	6.717	5468.5	-6.622	3.080
		3.293	0.163E-05	2.214	1.597	6.726	5491.0	-5.787	3.088

LOAD INCREMENT #13 S.D.= 186 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	10.964	3.298	0.222E+01	2.218	1.596	6.736	5491.0	0.346	-2.000
0.5	10.963	3.302	0.374E-04	2.219	1.596	6.740	5491.5	-4.427	-0.301
8.5	10.961	3.307	0.458E-05	2.223	1.596	6.748	5499.5	-5.339	0.929
23.5	10.958	3.314	0.327E-05	2.228	1.595	6.760	5514.5	-5.486	1.371
47.5	11.054	3.323	0.254E-05	2.234	1.609	6.786	5538.5	-5.584	1.677
97.5	11.146	3.344	0.281E-05	2.248	1.623	6.832	5588.5	-5.551	1.989
119.5	11.242	3.355	0.334E-05	2.258	1.636	6.861	5610.5	-5.477	2.077
146.8	11.337	3.367	0.295E-05	2.284	1.650	6.892	5637.5	-5.531	2.186
167.5	11.386	3.369	0.874E-06	2.285	1.657	6.902	5658.5	-6.059	2.224
191.5	11.433	3.377	0.229E-05	2.271	1.664	6.921	5682.5	-5.840	2.282
215.5	11.430	3.386	0.230E-05	2.278	1.664	6.934	5706.5	-5.639	2.333
244.5	11.527	3.395	0.211E-05	2.282	1.677	6.951	5735.5	-5.676	2.388
268.5	11.625	3.398	0.102E-05	2.285	1.692	6.978	5759.5	-5.991	2.429
287.5	11.622	3.405	0.258E-05	2.290	1.691	6.980	5778.5	-5.589	2.459
311.5	11.670	3.412	0.178E-05	2.284	1.698	7.006	5802.5	-5.748	2.493
335.5	11.716	3.421	0.255E-05	2.300	1.705	7.026	5826.5	-5.593	2.526
359.5	11.764	3.426	0.153E-05	2.304	1.712	7.041	5850.5	-5.815	2.556
383.5	11.812	3.432	0.178E-06	2.308	1.719	7.057	5874.5	-5.748	2.584
432.5	11.908	3.443	0.150E-05	2.316	1.732	7.086	5923.5	-5.825	2.636
456.5	11.956	3.448	0.180E-05	2.319	1.739	7.101	5946.5	-5.797	2.658
479.5	12.003	3.455	0.179E-05	2.324	1.746	7.117	5970.5	-5.748	2.681
503.5	12.051	3.459	0.128E-05	2.327	1.753	7.130	5994.5	-5.894	2.702
527.5	12.099	3.466	0.204E-05	2.331	1.760	7.148	6018.5	-5.691	2.722
551.5	12.096	3.472	0.153E-05	2.335	1.760	7.157	6042.5	-5.815	2.742
604.0	12.193	3.481	0.117E-05	2.341	1.774	7.183	6095.0	-5.933	2.781
623.5	12.241	3.486	0.189E-05	2.345	1.780	7.198	6114.5	-5.724	2.795
647.5	12.289	3.492	0.153E-05	2.349	1.802	7.224	6138.5	-5.815	2.811
671.5	12.417	3.497	0.153E-05	2.352	1.808	7.236	6162.5	-5.816	2.827
695.5	12.436	3.498	0.511E-06	2.354	1.809	7.242	6186.5	-6.292	2.842
719.5	12.484	3.503	0.128E-05	2.357	1.816	7.255	6210.5	-5.894	2.857

LOAD INCREMENT #14 S.D.= 229 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	12.266	4.063	0.274E+01	2.736	1.784	8.164	6210.5	0.437	-2.000
1.0	12.264	4.069	0.373E-04	2.742	1.784	8.173	6211.5	-4.428	0.0
3.0	12.261	4.076	0.246E-04	2.747	1.783	8.185	6213.5	-4.609	0.477
9.0	12.257	4.085	0.102E-04	2.753	1.783	8.199	6219.5	-4.990	0.954
19.0	12.399	4.105	0.141E-04	2.767	1.803	8.251	6229.5	-4.848	1.279
39.5	12.443	4.122	0.540E-05	2.778	1.810	8.283	6250.0	-5.268	1.597
63.0	12.536	4.139	0.497E-05	2.790	1.823	8.323	6273.5	-5.303	1.799
87.0	12.629	4.159	0.564E-05	2.803	1.836	8.367	6297.5	-5.249	1.940
111.0	12.643	4.173	0.410E-05	2.813	1.839	8.392	6321.5	-5.387	2.045
135.0	12.718	4.186	0.385E-05	2.823	1.849	8.424	6345.5	-5.415	2.130
153.0	12.813	4.198	0.445E-05	2.831	1.863	8.455	6363.5	-5.352	2.185
209.5	12.906	4.216	0.218E-05	2.843	1.876	8.496	6420.0	-5.662	2.321
231.5	13.002	4.226	0.308E-05	2.850	1.890	8.524	6442.0	-5.512	2.365
255.0	13.050	4.233	0.209E-05	2.855	1.897	8.541	6465.5	-5.679	2.407
279.0	13.095	4.245	0.334E-05	2.863	1.904	8.566	6489.5	-5.477	2.446
303.0	13.122	4.254	0.257E-05	2.869	1.907	8.584	6513.5	-5.591	2.481
327.0	13.168	4.262	0.231E-05	2.874	1.917	8.606	6537.5	-5.637	2.515
351.0	13.216	4.268	0.180E-05	2.879	1.921	8.620	6561.5	-5.745	2.545
377.5	13.263	4.276	0.186E-05	2.883	1.931	8.639	6588.0	-5.731	2.577
399.0	13.381	4.282	0.201E-05	2.888	1.945	8.662	6609.5	-5.698	2.601
423.0	13.378	4.289	0.205E-05	2.893	1.944	8.673	6633.5	-5.888	2.626
447.0	13.424	4.300	0.308E-05	2.900	1.951	8.697	6657.5	-5.511	2.650
471.0	13.472	4.305	0.154E-05	2.904	1.958	8.711	6681.5	-5.813	2.673
499.0	13.569	4.311	0.132E-05	2.908	1.972	8.732	6709.5	-5.880	2.698
544.5	13.664	4.325	0.216E-05	2.917	1.985	8.767	6755.0	-6.865	2.736
567.0	13.661	4.331	0.192E-05	2.922	1.985	8.777	6777.5	-5.717	2.754
591.0	13.739	4.338	0.180E-05	2.926	1.996	8.797	6801.5	-5.745	2.772
615.0	13.757	4.342	0.128E-05	2.928	1.999	8.807	6825.5	-5.892	2.789
663.0	13.852	4.356	0.205E-05	2.939	2.012	8.842	6873.5	-5.888	2.822
687.0	13.930	4.361	0.128E-05	2.942	2.024	8.859	6897.5	-5.891	2.837
711.0	13.998	4.366	0.154E-05	2.946	2.033	8.876	6921.5	-5.813	2.852
735.0	14.047	4.369	0.772E-06	2.948	2.041	8.886	6945.5	-6.112	2.866
759.0	14.045	4.374	0.153E-05	2.951	2.040	8.895	6969.5	-5.814	2.880
783.0	14.043	4.378	0.103E-05	2.954	2.040	8.901	6993.5	-5.988	2.894
807.0	14.042	4.382	0.103E-05	2.956	2.040	8.907	7017.5	-5.988	2.907

LOAD INCREMENT #15 S.D.= 281 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	14.041	4.383	0.298E+01	2.957	2.040	8.909	7017.5	0.471	-2.000
1.0	14.038	4.387	0.311E-04	2.960	2.039	8.916	7018.5	-4.507	0.0
5.5	14.036	4.398	0.123E-04	2.966	2.039	8.929	7023.0	-4.909	0.740
8.0	14.035	4.400	0.123E-04	2.968	2.038	8.937	7025.5	-4.909	0.903
25.0	14.128	4.418	0.725E-05	2.981	2.052	8.978	7042.5	-5.140	1.398
49.0	14.220	4.438	0.585E-05	2.995	2.065	9.022	7066.5	-5.248	1.890
73.0	14.311	4.459	0.817E-05	3.009	2.079	9.069	7090.5	-5.210	1.863
100.0	14.403	4.481	0.548E-05	3.024	2.092	9.116	7117.5	-5.261	2.000
121.0	14.451	4.486	0.147E-05	3.027	2.089	9.129	7138.5	-5.833	2.083
147.0	14.493	4.507	0.588E-05	3.042	2.105	9.170	7164.5	-5.245	2.167
168.0	14.588	4.519	0.382E-05	3.050	2.118	9.201	7185.5	-5.418	2.225
199.0	14.634	4.531	0.259E-05	3.058	2.125	9.226	7216.5	-5.588	2.299
217.5	14.681	4.537	0.234E-05	3.062	2.132	9.242	7235.0	-5.632	2.337
240.0	14.676	4.550	0.411E-05	3.072	2.131	9.284	7257.5	-5.386	2.380
264.0	14.773	4.557	0.180E-05	3.076	2.145	9.286	7281.5	-6.745	2.422
288.0	14.769	4.567	0.309E-05	3.083	2.144	9.304	7305.5	-5.511	2.459
312.0	14.815	4.577	0.283E-05	3.090	2.151	9.326	7329.5	-5.548	2.494
337.0	14.912	4.586	0.246E-05	3.096	2.165	9.352	7354.5	-5.608	2.528
386.0	14.958	4.595	0.126E-05	3.103	2.172	9.373	7403.5	-5.800	2.587
408.0	14.875	4.604	0.281E-05	3.108	2.174	9.390	7425.5	-5.552	2.611
432.0	15.051	4.614	0.283E-05	3.116	2.185	9.415	7449.5	-5.549	2.635
456.0	15.048	4.622	0.232E-05	3.121	2.184	9.429	7473.5	-5.835	2.659
480.0	15.145	4.630	0.231E-05	3.127	2.198	9.454	7497.5	-5.836	2.681
504.0	15.143	4.636	0.155E-05	3.130	2.198	9.462	7521.5	-5.811	2.702
554.0	15.238	4.648	0.173E-05	3.139	2.212	9.495	7571.5	-5.763	2.744
576.0	15.334	4.658	0.337E-05	3.146	2.225	9.524	7593.5	-5.472	2.760
600.0	15.432	4.663	0.103E-05	3.148	2.240	9.542	7617.5	-5.888	2.778
624.0	15.480	4.668	0.154E-05	3.153	2.246	9.556	7641.5	-5.812	2.795
648.0	15.526	4.677	0.257E-05	3.159	2.253	9.577	7665.5	-5.590	2.812
672.0	15.575	4.681	0.103E-05	3.161	2.280	9.588	7689.5	-5.987	2.827
697.0	15.622	4.690	0.247E-05	3.167	2.267	9.609	7714.5	-5.807	2.843
722.0	15.721	4.693	0.741E-06	3.169	2.281	9.625	7739.5	-6.130	2.859
744.0	15.718	4.699	0.196E-05	3.174	2.281	9.636	7761.5	-5.708	2.872
768.0	15.736	4.705	0.180E-05	3.178	2.283	9.648	7785.5	-5.744	2.885
792.0	15.813	4.711	0.180E-05	3.182	2.294	9.658	7809.5	-5.744	2.899
816.0	15.861	4.716	0.129E-05	3.185	2.301	9.681	7833.5	-5.890	2.912
840.0	15.909	4.723	0.208E-05	3.190	2.308	9.699	7857.5	-5.888	2.924
889.5	16.006	4.729	0.872E-06	3.195	2.322	9.721	7907.0	-6.080	2.949
911.5	16.003	4.737	0.225E-05	3.199	2.322	9.733	7929.0	-5.649	2.960
935.0	16.051	4.742	0.158E-05	3.203	2.328	9.747	7952.5	-5.802	2.971
959.0	16.100	4.746	0.103E-05	3.206	2.335	9.759	7976.5	-5.987	2.982
983.0	16.100	4.746	0.0	3.206	2.335	9.759	8000.5	-5.991	2.980
1007.0	16.097	4.753	0.205E-05	3.211	2.335	9.771	8024.5	-5.888	3.003
1056.0	16.090	4.771	0.252E-05	3.223	2.334	9.800	8073.5	-5.598	3.024
1082.0	16.191	4.769	-0.478E-06	3.222	2.348	9.809	8098.5	-5.395	3.034
1103.0	16.340	4.771	0.589E-06	3.223	2.370	9.830	8120.5	-6.230	3.043
1127.0	16.338	4.777	0.180E-05	3.227	2.369	9.840	8144.5	-5.744	3.052
1151.0	16.387	4.779	0.515E-06	3.228	2.377	9.848	8168.5	-6.288	3.061
1180.0	16.384	4.786	0.170E-05	3.233	2.376	9.860	8197.5	-5.769	3.072
1225.0	16.562	4.791	0.687E-06	3.237	2.405	9.881	8242.5	-6.163	3.088
1247.5	16.560	4.796	0.185E-05	3.240	2.404	9.900	8265.0	-5.783	3.096
1271.5	16.628	4.800	0.129E-05	3.243	2.411	9.913	8289.0	-5.890	3.104
1295.5	16.677	4.804	0.103E-05	3.246	2.418	9.925	8313.0	-5.988	3.112
1319.5	16.676	4.807	0.775E-06	3.248	2.418	9.929	8337.0	-6.111	3.120

LOAD INCREMENT #16 S.D = 294 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	16.674	4.811	0.325E+01	3.250	2.418	9.936	8337.0	0.512	-2.000
1.0	16.673	4.815	0.312E-04	3.254	2.403	9.932	8338.0	-4.506	0.0
2.0	16.673	4.815	0.0	3.254	2.403	9.932	8339.0	-4.909	0.740
8.0	16.668	4.827	0.134E-04	3.262	2.417	9.962	8345.0	-4.873	0.903
27.0	16.763	4.840	0.456E-05	3.270	2.430	9.995	8364.0	-5.341	1.431
50.0	16.858	4.853	0.403E-05	3.279	2.444	10.029	8387.0	-5.395	1.698
72.5	16.854	4.862	0.275E-05	3.286	2.443	10.043	8409.5	-5.561	1.860
95.5	16.948	4.879	0.510E-05	3.297	2.457	10.083	8432.5	-5.292	1.980
119.5	16.991	4.897	0.516E-05	3.310	2.463	10.118	8456.5	-5.288	2.077
143.5	17.038	4.904	0.206E-05	3.315	2.470	10.136	8480.5	-5.687	2.157
167.5	17.034	4.914	0.284E-05	3.322	2.469	10.152	8504.5	-5.547	2.224
191.5	17.129	4.928	0.387E-05	3.331	2.483	10.186	8528.5	-5.413	2.282
215.5	17.127	4.933	0.148E-05	3.334	2.483	10.195	8553.5	-5.829	2.335
240.5	17.123	4.942	0.258E-05	3.341	2.482	10.209	8577.5	-5.569	2.381
263.5	17.117	4.959	0.511E-05	3.352	2.481	10.237	8600.5	-5.292	2.421
287.5	17.114	4.966	0.180E-05	3.357	2.481	10.248	8624.5	-5.744	2.459
311.5	17.411	4.974	0.232E-05	3.362	2.523	10.296	8648.5	-5.835	2.493
335.5	17.408	4.982	0.127E-05	3.368	2.523	10.309	8692.5	-5.897	2.551
359.5	17.504	4.991	0.154E-04	3.374	2.536	10.336	8696.5	-4.611	2.556
455.5	17.596	5.011	0.148E-05	3.388	2.550	10.381	8792.5	-5.829	2.658
479.5	17.594	5.018	0.181E-05	3.393	2.564	10.403	8816.5	-5.743	2.681
503.5	17.592	5.022	0.128E-05	3.386	2.563	10.411	8840.5	-5.891	2.702
527.5	17.640	5.029	0.181E-05	3.400	2.556	10.415	8864.5	-5.743	2.722
576.5	17.788	5.038	0.139E-05	3.407	2.577	10.449	8913.5	-5.857	2.761
601.0	17.682	5.047	0.228E-05	3.412	2.562	10.451	8938.0	-5.643	2.779
623.5	17.679	5.056	0.302E-05	3.419	2.561	10.467	8960.5	-5.519	2.795
647.5	17.877	5.061	0.129E-05	3.422	2.590	10.498	8984.5	-5.888	2.811
671.5	17.824	5.069	0.232E-05	3.428	2.587	10.517	9008.5	-5.634	2.827
699.5	18.071	5.075	0.155E-05	3.432	2.618	10.545	9036.5	-5.810	2.845
744.5	18.066	5.088	0.192E-05	3.441	2.617	10.566	9081.5	-5.716	2.872
767.5	18.065	5.092	0.135E-05	3.444	2.617	10.573	9104.5	-5.871	2.885
793.5	18.161	5.101	0.214E-05	3.450	2.631	10.598	9130.5	-5.669	2.900
815.5	18.210	5.105	0.141E-05	3.453	2.637	10.611	9152.5	-5.851	2.911
839.5	18.258	5.110	0.154E-05	3.456	2.644	10.625	9176.5	-5.811	2.924
863.5	18.263	5.121	0.310E-05	3.464	2.644	10.643	9200.5	-5.509	2.936
912.5	18.501	5.128	0.885E-06	3.468	2.679	10.683	9249.5	-6.053	2.960
935.5	18.548	5.133	0.162E-05	3.472	2.686	10.697	9272.5	-5.792	2.971
959.5	18.547	5.137	0.103E-05	3.474	2.686	10.703	9296.5	-5.988	2.982

PLOT 1, 641 UNPLOTTABLE POINTS

GEOTECHNICAL LABORATORIES
DEPARTMENT OF CIVIL ENGINEERING
UNIVERSITY OF MANITOBA

CONSTANT CELL PRESSURE MULTI-STAGE TRIAXIAL CREEP TEST

MST11 – σ_3 =70 kPa

LOAD INCREMENT # 1 S.D.= 0 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	0.980	0.0	0.0	0.0	0.144	0.117	0.0	0.0	0.0
0.0	-1.721	0.002	0.125E-02	0.001	-0.253	0.203	0.0	-2.905	-1.699
0.5	-2.074	0.010	0.115E-03	0.007	-0.305	0.232	0.5	-3.938	-0.301
1.3	-2.129	0.024	0.123E-03	0.018	-0.313	0.216	1.3	-3.910	0.097
4.3	-2.031	0.029	0.103E-04	0.019	-0.299	0.197	4.3	-4.988	0.628
24.0	-2.134	0.037	0.281E-05	0.025	-0.314	0.196	24.0	-5.552	1.380
49.0	-2.136	0.042	0.123E-05	0.028	-0.314	0.189	49.0	-5.911	1.690
71.0	-2.138	0.045	0.112E-05	0.030	-0.314	0.183	71.0	-5.948	1.851
95.0	-2.238	0.047	0.512E-06	0.031	-0.329	0.192	95.0	-6.291	1.978
119.0	-2.240	0.052	0.128E-05	0.034	-0.329	0.184	119.0	-5.891	2.076
143.0	-2.240	0.053	0.253E-06	0.035	-0.329	0.183	143.0	-6.596	2.155
167.0	-2.242	0.056	0.103E-05	0.038	-0.330	0.177	167.0	-5.989	2.223
192.0	-2.242	0.056	0.0	0.038	-0.330	0.177	192.0	0.0	0.0
221.0	-2.389	0.049	-0.170E-05	0.033	-0.351	0.207	221.0	0.0	0.0
238.0	-2.392	0.055	0.254E-05	0.037	-0.362	0.197	238.0	-5.595	2.377
262.0	-2.342	0.056	0.253E-06	0.038	-0.344	0.189	262.0	-6.596	2.418
286.0	-2.393	0.059	0.773E-06	0.039	-0.352	0.191	286.0	-6.112	2.456
310.0	-2.444	0.061	0.512E-06	0.041	-0.359	0.194	310.0	-6.291	2.491
334.0	-2.344	0.062	0.258E-06	0.041	-0.345	0.180	334.0	-6.588	2.524
358.0	-2.345	0.064	0.491E-06	0.043	-0.345	0.177	358.0	-6.309	2.555
388.0	-2.343	0.060	-0.847E-06	0.040	-0.345	0.183	388.0	0.0	0.0
407.0	-2.393	0.060	0.0	0.040	-0.352	0.189	407.0	0.0	0.0

LOAD INCREMENT # 2 S.D.= 16 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	0.005	-0.012	-0.772E-02	-0.008	0.001	0.018	0.0	0.0	0.0
0.5	-0.085	-0.013	-0.136E-04	-0.008	-0.010	0.028	0.5	-2.905	-1.699
1.0	-0.146	-0.010	0.381E-04	-0.006	-0.022	0.033	1.0	-4.419	0.0
3.0	-0.127	-0.007	0.906E-05	-0.005	-0.019	0.027	3.0	-5.043	0.477
7.0	-0.047	-0.008	-0.143E-05	-0.005	-0.007	0.018	7.0	-4.988	0.628
23.0	0.051	-0.003	0.191E-05	-0.002	0.008	0.001	23.0	-5.720	1.362
31.0	0.050	-0.001	0.226E-05	-0.000	0.007	0.005	31.0	-5.645	1.491
46.0	0.099	0.002	0.123E-05	0.001	0.015	0.015	46.0	-5.911	1.663
71.5	0.098	0.004	0.482E-06	0.003	0.014	0.018	71.5	-6.317	1.854
95.0	0.098	0.005	0.264E-06	0.003	0.014	0.020	95.0	-6.579	1.978
121.0	0.097	0.009	0.947E-06	0.006	0.014	0.026	121.0	-6.024	2.083
146.0	0.140	0.025	0.444E-05	0.017	0.021	0.058	146.0	-5.353	2.164
173.0	0.143	0.018	-0.182E-05	0.012	0.021	0.046	173.0	0.0	0.0
202.5	0.142	0.022	0.835E-06	0.014	0.021	0.052	202.5	-6.079	2.306
226.5	0.142	0.021	-0.258E-06	0.014	0.021	0.051	226.5	-5.595	2.377

LOAD INCREMENT # 3 S.D.= 33 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	0.145	0.013	0.834E-02	0.008	0.021	0.038	226.5	-2.079	-2.000
0.5	0.097	0.009	-0.502E-04	0.006	0.014	0.026	227.0	-2.905	-1.699
1.3	-0.002	0.005	-0.330E-04	0.003	-0.000	0.008	227.7	-4.419	0.0
4.3	0.042	0.020	0.329E-04	0.013	0.006	0.038	230.7	-4.483	0.628
7.3	0.085	0.038	0.411E-04	0.026	0.012	0.073	233.7	-4.386	0.860
24.0	0.139	0.027	-0.441E-05	0.018	0.021	0.061	250.5	-5.720	1.362
47.5	0.346	0.011	-0.472E-05	0.007	0.051	0.059	274.0	-5.645	1.491
55.5	-0.308	0.149	0.118E-03	0.100	-0.045	0.207	282.0	-3.937	1.744
73.5	-0.461	0.157	0.274E-05	0.104	-0.068	0.200	300.0	-5.562	1.866
97.0	-0.700	0.772	0.175E-03	0.516	-0.103	1.180	323.5	-3.757	1.987
120.0	2.240	0.541	-0.672E-04	0.361	0.329	1.154	346.5	-6.024	2.083
129.5	2.359	0.749	0.147E-03	0.501	0.347	1.509	356.0	-3.834	2.112
142.5	1.671	0.589	-0.823E-04	0.393	0.248	1.165	369.0	0.0	0.0
167.0	4.750	0.516	-0.199E-04	0.345	0.697	1.414	393.5	-6.079	2.306
191.0	4.650	0.516	0.0	0.345	0.683	1.402	417.5	-5.595	2.377
215.0	4.653	0.509	-0.208E-05	0.340	0.683	1.390	441.5	-6.596	2.418
264.0	4.652	0.511	0.378E-06	0.342	0.683	1.394	490.5	-6.422	2.422
287.0	4.650	0.515	0.107E-05	0.344	0.683	1.400	513.5	-5.969	2.458
311.0	4.751	0.514	-0.254E-06	0.343	0.697	1.411	537.5	-6.588	2.524
335.0	4.850	0.515	0.254E-06	0.344	0.712	1.424	561.5	-6.595	2.525
359.0	4.851	0.514	-0.254E-06	0.343	0.712	1.422	585.5	0.0	0.0
383.0	4.951	0.512	-0.518E-06	0.342	0.727	1.432	609.5	0.0	0.0
439.0	5.245	0.528	0.188E-05	0.353	0.770	1.492	665.5	-5.727	2.642

GEOTECHNICAL LABORATORIES
DEPARTMENT OF CIVIL ENGINEERING
UNIVERSITY OF MANITOBA

CONSTANT CELL PRESSURE MULTI-STAGE TRIAXIAL CREEP TEST
MST12 – σ_3 =70 kPa

LOAD INCREMENT # 1 S.D.= 0 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	-2.473	-0.080	-0.387E-01	-0.040	-0.363	0.383	0.0	0.0	0.0
0.8	-2.873	0.006	0.533E-03	0.004	-0.436	0.348	0.8	-3.273	-0.081
5.8	-2.778	0.020	0.187E-04	0.013	-0.408	0.300	5.8	-4.727	0.760
23.2	-2.880	0.022	0.987E-06	0.015	-0.423	0.308	23.2	-6.006	1.365
48.2	-2.880	0.023	0.234E-06	0.016	-0.437	0.319	48.2	-6.631	1.883
70.2	-2.880	0.023	0.0	0.016	-0.437	0.319	70.2	0.0	0.0
94.7	-2.880	0.022	-0.474E-06	0.014	-0.437	0.322	94.7	0.0	0.0
118.2	-2.880	0.022	0.246E-06	0.015	-0.437	0.320	118.2	-6.608	2.073
142.2	-2.880	0.023	0.243E-06	0.016	-0.437	0.319	142.2	-6.814	2.163
166.2	-2.882	0.027	0.961E-06	0.018	-0.423	0.301	166.2	-6.017	2.221
191.2	-2.882	0.027	0.0	0.018	-0.423	0.301	191.2	0.0	0.0
221.0	-3.030	0.023	-0.774E-06	0.016	-0.445	0.325	221.0	0.0	0.0
238.0	-3.032	0.027	0.136E-06	0.018	-0.445	0.319	238.0	-5.867	2.377
262.0	-2.982	0.026	-0.243E-06	0.017	-0.437	0.315	262.0	0.0	0.0
286.0	-2.982	0.026	0.0	0.017	-0.437	0.315	286.0	0.0	0.0
310.0	-2.982	0.026	0.0	0.017	-0.437	0.315	310.0	0.0	0.0
334.0	-2.982	0.026	0.0	0.017	-0.437	0.315	334.0	0.0	0.0
359.5	-3.032	0.028	0.451E-06	0.018	-0.445	0.318	359.5	-6.346	2.556
388.0	-2.982	0.026	-0.404E-06	0.017	-0.437	0.315	388.0	0.0	0.0
407.0	-2.982	0.027	0.307E-06	0.018	-0.438	0.313	407.0	-6.512	2.610

LOAD INCREMENT # 2 S.D.= 16 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	-0.002	0.004	0.282E-02	0.003	-0.000	0.007	0.0	-2.550	-2.000
0.5	-0.106	0.013	0.118E-03	0.009	-0.016	0.008	0.5	-3.929	-0.301
2.5	-0.062	0.028	0.489E-04	0.018	-0.009	0.037	2.5	-4.310	0.398
6.5	-0.012	0.027	-0.145E-05	0.018	-0.002	0.042	6.5	-6.006	1.365
22.5	0.036	0.030	0.144E-05	0.020	0.005	0.054	22.5	-5.841	1.352
30.5	0.085	0.033	0.216E-05	0.022	0.012	0.064	30.5	-5.667	1.484
45.5	0.084	0.036	0.154E-05	0.024	0.012	0.069	45.5	-5.812	1.658
71.0	0.082	0.041	0.113E-05	0.027	0.012	0.076	71.0	-5.948	1.851
94.5	0.081	0.043	0.736E-06	0.029	0.012	0.080	94.5	-6.133	1.975
120.5	0.130	0.044	0.222E-06	0.029	0.019	0.087	120.5	-6.653	2.081
145.5	0.224	0.058	0.369E-05	0.039	0.033	0.121	145.5	-5.433	2.163
172.5	0.227	0.051	-0.171E-05	0.034	0.033	0.110	172.5	0.0	0.0
202.0	0.228	0.050	-0.194E-06	0.033	0.033	0.109	202.0	-5.867	2.377
226.0	0.227	0.051	0.239E-06	0.034	0.033	0.110	226.0	-6.623	2.354

LOAD INCREMENT # 3 S.D.= 33 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	0.180	0.044	0.296E-01	0.030	0.026	0.084	226.0	-1.529	-2.000
1.0	0.071	0.065	0.140E-03	0.043	0.010	0.115	227.0	-3.855	0.0
4.0	0.165	0.079	0.307E-04	0.053	0.024	0.149	230.0	-4.512	0.602
7.0	0.154	0.103	0.538E-04	0.069	0.023	0.167	233.0	-4.269	0.845
23.5	0.160	0.089	-0.559E-05	0.060	0.023	0.165	249.5	-5.841	1.352
47.0	0.442	0.130	0.115E-04	0.087	0.065	0.265	273.0	-4.938	1.672
55.0	-1.115	0.256	0.105E-03	0.171	-0.164	0.285	281.0	-3.978	1.740
73.0	-1.168	0.264	0.289E-05	0.176	-0.172	0.291	299.0	-5.540	1.863

LOAD INCREMENT # 4 S.D.= 33 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
96.5	-4.123	0.274	0.190E-04	0.183	-0.608	0.048	395.5	-4.722	1.985
119.5	-1.809	0.020	-0.737E-04	0.013	-0.266	0.185	418.5	-3.855	0.0
129.0	-3.637	0.306	0.200E-03	0.204	-0.536	0.061	428.0	-3.698	2.111
142.0	-1.035	-0.033	-0.173E-03	-0.022	-0.152	0.177	441.0	-4.269	0.845
166.5	-1.088	-0.026	0.187E-05	-0.017	-0.160	0.173	465.5	-5.729	2.221
190.5	-1.086	-0.031	-0.143E-05	-0.021	-0.160	0.161	489.5	-4.938	1.672
214.5	-1.087	-0.030	0.238E-06	-0.020	-0.160	0.179	513.5	-6.623	2.331
263.5	0.012	-0.027	0.467E-06	-0.018	0.002	0.042	562.5	-6.331	2.421
286.5	0.112	-0.026	0.249E-06	-0.017	0.016	0.028	585.5	-6.504	2.457
310.5	0.112	-0.026	0.0	-0.017	0.016	0.028	609.5	-6.653	2.081
334.5	0.211	-0.024	0.477E-06	-0.016	0.031	0.014	633.5	-6.322	2.524
358.5	0.211	-0.025	-0.238E-06	-0.016	0.031	0.015	657.5	0.0	0.0
382.5	0.311	-0.025	0.0	-0.016	0.046	0.003	681.5	-5.867	2.377
438.5	0.806	-0.013	0.145E-05	-0.008	0.089	0.052	737.5	-5.838	2.642
502.5	0.806	-0.014	-0.179E-06	-0.010	0.089	0.049	801.5	0.0	0.0

LOAD INCREMENT # 5 S.D.= 49 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	0.602	-0.005	-0.334E-02	-0.003	0.088	0.084	801.5	-4.722	1.985
0.8	0.609	-0.021	-0.140E-03	-0.014	0.090	0.039	802.2	-3.855	0.0
2.3	0.609	-0.020	0.381E-05	-0.013	0.088	0.041	803.7	-5.419	0.352
4.8	0.609	-0.021	-0.229E-05	-0.014	0.090	0.039	806.2	-4.269	0.845
23.0	0.660	-0.022	-0.313E-06	-0.014	0.097	0.044	824.5	-5.729	2.221
47.0	0.710	-0.022	0.0	-0.014	0.104	0.050	848.5	-4.938	1.672
69.0	0.758	-0.019	0.780E-06	-0.013	0.111	0.060	870.5	-6.108	1.839
96.5	10.809	-0.019	0.0	-0.013	1.577	1.256	898.0	-6.331	2.421
117.0	0.757	-0.016	0.112E-05	-0.010	0.111	0.066	918.5	-5.952	2.068

LOAD INCREMENT # 6 S.D.= 65 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	0.758	-0.019	-0.126E-01	-0.013	0.111	0.060	918.5	-4.722	1.985
0.8	0.709	-0.020	-0.773E-05	-0.013	0.104	0.053	919.2	-3.855	0.0
2.3	0.754	-0.009	0.464E-04	-0.006	0.111	0.075	920.7	-4.333	0.352
9.3	0.806	-0.014	-0.409E-05	-0.009	0.118	0.074	927.7	-4.269	0.845
24.0	0.806	-0.014	0.0	-0.009	0.118	0.074	942.5	-5.729	2.221
48.0	0.807	-0.015	-0.238E-06	-0.010	0.118	0.073	966.5	-4.938	1.672
73.5	0.856	-0.013	0.449E-06	-0.008	0.126	0.082	992.0	-6.348	1.866
101.0	0.904	-0.009	0.832E-06	-0.006	0.133	0.093	1019.5	-6.080	2.004
120.0	0.904	-0.009	0.0	-0.006	0.133	0.093	1038.5	-5.952	2.068
144.0	0.905	-0.010	-0.238E-06	-0.007	0.133	0.092	1062.5	-6.653	2.081

LOAD INCREMENT # 7 S.D.= 82 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	0.907	-0.015	-0.102E-01	-0.010	0.133	0.084	1062.5	-4.722	1.985
0.8	0.907	-0.015	0.0	-0.010	0.133	0.084	1063.2	-3.855	0.0
2.3	0.896	0.010	0.111E-03	0.006	0.132	0.123	1064.7	-3.954	0.352
7.3	0.905	-0.012	-0.287E-04	-0.008	0.133	0.089	1069.7	-4.269	0.845
23.0	1.001	-0.002	0.442E-05	-0.001	0.147	0.118	1085.5	-5.355	1.382
47.0	1.000	0.000	0.445E-06	0.000	0.147	0.120	1109.5	-6.352	1.872
71.0	1.048	0.002	0.478E-06	0.001	0.154	0.129	1133.5	-6.318	1.851
97.0	1.099	0.003	0.222E-06	0.002	0.161	0.136	1159.5	-6.653	1.987
123.0	1.246	0.008	0.133E-05	0.005	0.183	0.162	1185.5	-5.876	2.090
144.0	1.243	0.015	0.220E-05	0.010	0.183	0.173	1206.5	-5.858	2.158

LOAD INCREMENT # 8 S.D.= 98 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	1.195	0.010	0.576E-02	0.007	0.176	0.160	1206.5	-2.170	-2.000
1.0	1.193	0.016	0.407E-04	0.011	0.175	0.159	1207.5	-4.390	0.0
4.5	1.240	0.022	0.115E-04	0.015	0.182	0.185	1211.0	-4.938	0.653
7.0	1.190	0.021	-0.229E-05	0.014	0.175	0.178	1213.5	-4.269	0.845
23.0	1.234	0.035	0.576E-05	0.023	0.181	0.205	1229.5	-5.240	1.362
74.0	1.272	0.063	0.362E-05	0.042	0.187	0.255	1280.5	-5.442	1.869
121.0	1.278	0.050	-0.184E-05	0.033	0.188	0.235	1327.5	-6.319	1.851
144.5	1.377	0.051	0.246E-06	0.034	0.202	0.248	1351.0	-6.609	2.160
171.5	1.474	0.058	0.170E-05	0.038	0.216	0.271	1378.0	-5.768	2.234
218.0	1.522	0.063	0.746E-06	0.042	0.223	0.285	1424.5	-6.128	2.338
243.5	1.551	0.065	0.456E-06	0.043	0.228	0.291	1450.0	-6.341	2.386
270.0	1.571	0.065	0.0	0.043	0.231	0.294	1476.5	0.0	0.0
289.5	1.571	0.064	-0.300E-06	0.042	0.231	0.292	1496.0	-5.867	2.377
312.5	1.572	0.063	-0.251E-06	0.042	0.231	0.291	1519.0	-5.839	2.642

LOAD INCREMENT # 9 S.D.= 114 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	1.572	0.062	0.415E+01	0.042	0.231	0.290	1518.0	-1.381	-2.000
1.0	1.572	0.063	0.578E-05	0.042	0.231	0.292	1520.0	-5.238	0.0
4.0	1.569	0.068	0.115E-04	0.046	0.230	0.300	1523.0	-4.937	0.602
23.0	1.570	0.067	-0.809E-06	0.044	0.231	0.297	1542.0	-4.269	0.845
47.0	1.565	0.078	0.336E-05	0.053	0.244	0.328	1566.0	-5.473	1.672
71.0	1.562	0.086	0.192E-05	0.057	0.288	0.375	1590.0	-5.717	1.851
95.0	1.986	0.099	0.360E-05	0.066	0.281	0.399	1614.0	-5.443	1.978
126.5	2.053	0.104	0.110E-05	0.069	0.301	0.416	1645.5	-5.960	2.102
145.0	2.053	0.106	0.629E-06	0.070	0.301	0.418	1664.0	-6.202	2.161
167.0	2.101	0.108	0.786E-06	0.072	0.308	0.428	1686.0	-6.104	2.223

LOAD INCREMENT #10 S.D.= 131 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	2.103	0.105	0.701E-01	0.070	0.308	0.424	1686.0	-1.154	-2.000
1.0	2.050	0.110	0.349E-04	0.074	0.301	0.426	1687.0	-4.457	0.0
4.0	2.126	0.120	0.212E-04	0.080	0.312	0.450	1690.0	-4.675	0.602
23.0	2.135	0.145	0.880E-05	0.097	0.313	0.493	1709.0	-5.055	1.362
47.0	2.130	0.156	0.312E-05	0.104	0.313	0.510	1733.0	-5.506	1.672
71.0	2.177	0.162	0.168E-05	0.108	0.320	0.526	1757.0	-5.774	1.851
95.0	2.224	0.169	0.192E-05	0.113	0.326	0.543	1781.0	-5.716	1.978
122.0	2.318	0.183	0.341E-05	0.122	0.340	0.577	1808.0	-5.467	2.086
151.0	2.318	0.182	-0.198E-06	0.121	0.340	0.575	1837.0	-6.202	2.161
167.0	2.317	0.185	0.108E-05	0.123	0.340	0.579	1853.0	-5.966	2.223
191.0	2.316	0.188	0.952E-06	0.125	0.340	0.585	1877.0	-6.017	2.281
215.0	2.384	0.193	0.120E-05	0.128	0.347	0.598	1901.0	-5.920	2.332
239.0	2.412	0.195	0.721E-06	0.130	0.354	0.608	1925.0	-6.142	2.378
263.0	2.412	0.196	0.241E-06	0.131	0.354	0.609	1949.0	-6.618	2.420
312.5	2.461	0.199	0.464E-06	0.133	0.361	0.620	1998.5	-6.333	2.495
336.5	2.510	0.201	0.485E-06	0.134	0.368	0.629	2022.5	-6.314	2.527
359.0	2.510	0.201	0.0	0.134	0.368	0.629	2045.0	0.0	0.0

LOAD INCREMENT #11 S.D.= 147 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	2.511	0.199	0.133E+00	0.133	0.368	0.626	2045.0	-0.877	-2.000
1.5	2.509	0.203	0.155E-04	0.135	0.368	0.632	2046.5	-4.811	0.176
4.5	2.508	0.204	0.386E-05	0.136	0.372	0.638	2049.5	-5.413	0.653
7.5	2.551	0.206	0.384E-05	0.137	0.368	0.637	2052.5	-5.416	0.875
23.5	2.587	0.222	0.649E-05	0.148	0.374	0.667	2068.5	-5.188	1.371
47.5	2.580	0.252	0.842E-05	0.168	0.380	0.721	2092.5	-5.075	1.677
71.5	2.620	0.267	0.409E-05	0.178	0.379	0.745	2116.5	-5.388	1.854
103.5	2.663	0.290	0.487E-05	0.193	0.384	0.788	2148.5	-5.313	2.015
121.0	2.755	0.306	0.593E-05	0.204	0.381	0.818	2166.0	-5.227	2.083
143.5	2.748	0.323	0.513E-05	0.215	0.404	0.857	2188.5	-5.290	2.157
167.5	2.785	0.339	0.457E-05	0.226	0.403	0.883	2212.5	-5.340	2.224
191.5	2.819	0.367	0.770E-05	0.245	0.409	0.933	2236.5	-5.114	2.282
215.5	2.888	0.402	0.987E-05	0.268	0.414	0.995	2260.5	-5.006	2.333
242.5	2.895	0.472	0.173E-04	0.315	0.424	1.118	2287.5	-4.761	2.385
289.5	2.938	0.569	0.138E-04	0.380	0.425	1.277	2334.5	-4.861	2.462
311.5	2.983	0.584	0.447E-05	0.390	0.431	1.307	2356.5	-5.350	2.493
336.5	2.963	0.595	0.301E-05	0.397	0.438	1.330	2381.5	-5.522	2.527
359.5	2.963	0.595	0.0	0.397	0.438	1.330	2404.5	-6.346	2.556
383.5	3.031	0.600	0.145E-05	0.401	0.445	1.345	2428.5	-5.840	2.584
410.5	3.126	0.611	0.257E-05	0.408	0.458	1.373	2455.5	-5.590	2.613
460.0	3.125	0.613	0.233E-06	0.408	0.458	1.376	2505.0	-6.632	2.663
487.5	3.220	0.623	0.252E-05	0.416	0.472	1.404	2532.5	-5.598	2.688
506.5	3.219	0.627	0.153E-05	0.419	0.472	1.411	2551.5	-5.816	2.705

LOAD INCREMENT #12 S.D.= 163 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	3.220	0.624	0.417E+00	0.417	0.472	1.406	2551.5	-0.380	-2.000
1.5	3.118	0.629	0.194E-04	0.420	0.457	1.401	2553.0	-4.713	0.176
3.5	3.216	0.634	0.174E-04	0.423	0.472	1.421	2555.0	-4.761	0.544
8.5	3.286	0.655	0.278E-04	0.437	0.482	1.464	2560.0	-4.556	0.929
23.5	3.202	0.663	0.386E-05	0.443	0.470	1.468	2575.0	-5.413	1.371
47.5	3.240	0.690	0.747E-05	0.461	0.475	1.516	2599.0	-5.126	1.677
74.5	3.332	0.709	0.472E-05	0.473	0.489	1.559	2626.0	-5.326	1.872
121.0	3.389	0.737	0.398E-05	0.492	0.494	1.608	2672.5	-5.400	2.083
143.5	3.414	0.750	0.386E-05	0.501	0.501	1.635	2695.0	-5.413	2.157
167.5	3.460	0.757	0.217E-05	0.506	0.507	1.653	2719.0	-5.663	2.224
191.5	3.457	0.765	0.217E-05	0.511	0.507	1.666	2743.0	-5.663	2.282
215.5	3.451	0.777	0.338E-05	0.519	0.506	1.685	2767.0	-5.472	2.333
239.5	3.548	0.784	0.193E-05	0.524	0.520	1.708	2791.0	-5.714	2.379
286.0	3.593	0.796	0.174E-05	0.532	0.527	1.733	2837.5	-5.758	2.456
308.5	3.639	0.805	0.258E-05	0.538	0.533	1.753	2860.0	-5.588	2.488
332.5	3.637	0.809	0.966E-06	0.540	0.533	1.758	2884.0	-6.015	2.522
356.5	3.637	0.809	0.242E-06	0.541	0.533	1.760	2908.0	-6.616	2.552
380.5	3.635	0.814	0.121E-05	0.543	0.533	1.766	2932.0	-5.918	2.580
404.5	3.585	0.813	-0.242E-06	0.543	0.526	1.759	2956.0	-5.840	2.584
452.5	3.534	0.815	0.242E-06	0.544	0.518	1.756	3004.0	-6.616	2.656
476.5	3.584	0.815	0.0	0.544	0.526	1.762	3028.0	-6.632	2.663
500.5	3.732	0.821	0.159E-06	0.548	0.547	1.789	3052.0	-5.773	2.689
524.5	3.826	0.834	0.386E-05	0.557	0.561	1.823	3076.0	-5.413	2.720
548.5	3.920	0.847	0.338E-05	0.565	0.575	1.854	3100.0	-5.471	2.739
572.5	3.917	0.853	0.193E-05	0.570	0.574	1.865	3124.0	-5.715	2.756
605.5	4.010	0.869	0.316E-05	0.581	0.588	1.902	3157.0	-5.500	2.782
644.5	4.053	0.885	0.268E-05	0.591	0.594	1.933	3196.0	-5.572	2.809
668.5	4.099	0.893	0.242E-05	0.597	0.601	1.952	3220.0	-5.617	2.825
692.5	4.145	0.903	0.266E-05	0.603	0.608	1.973	3244.0	-5.576	2.840
716.5	4.142	0.910	0.193E-05	0.608	0.607	1.984	3268.0	-5.715	2.855
740.5	4.188	0.918	0.242E-05	0.614	0.614	2.004	3292.0	-5.617	2.870
790.0	4.280	0.937	0.246E-05	0.626	0.627	2.045	3341.5	-5.609	2.898
812.5	4.324	0.949	0.350E-05	0.634	0.634	2.070	3364.0	-5.443	2.910
836.5	4.370	0.957	0.242E-05	0.640	0.640	2.090	3388.0	-5.617	2.922
860.5	4.367	0.964	0.193E-05	0.644	0.640	2.101	3412.0	-5.715	2.935
884.5	4.415	0.969	0.145E-05	0.648	0.647	2.115	3436.0	-5.839	2.947
916.5	4.459	0.983	0.290E-05	0.657	0.653	2.143	3468.0	-5.538	2.962
958.0	4.505	0.991	0.128E-05	0.662	0.660	2.161	3509.5	-5.900	2.981
980.5	4.551	1.000	0.258E-05	0.668	0.667	2.181	3532.0	-5.589	2.991
1004.5	4.598	1.008	0.242E-05	0.674	0.674	2.201	3556.0	-5.617	3.002
1028.5	4.644	1.017	0.242E-05	0.680	0.680	2.220	3580.0	-5.617	3.012
1052.5	4.661	1.023	0.169E-05	0.684	0.683	2.232	3604.0	-6.772	3.022
1076.5	4.639	1.027	0.121E-05	0.687	0.680	2.237	3628.0	-5.918	3.032
1101.5	4.714	1.038	0.278E-05	0.694	0.691	2.263	3653.0	-5.555	3.042
1123.5	4.731	1.045	0.211E-05	0.698	0.693	2.276	3675.0	-5.675	3.051
1148.5	4.779	1.051	0.162E-05	0.702	0.700	2.292	3700.0	-5.790	3.060
1172.5	4.727	1.054	0.968E-06	0.705	0.693	2.291	3724.0	-6.014	3.069
1196.5	4.825	1.059	0.145E-05	0.708	0.707	2.312	3748.0	-5.838	3.078
1223.5	4.920	1.070	0.258E-05	0.715	0.721	2.340	3775.0	-5.589	3.088
1247.5	5.017	1.077	0.218E-05	0.720	0.735	2.364	3799.0	-5.662	3.096
1270.5	5.010	1.091	0.404E-05	0.730	0.734	2.386	3822.0	-5.394	3.104
1294.0	5.008	1.097	0.173E-05	0.734	0.734	2.386	3845.5	-5.762	3.112
1317.0	5.001	1.111	0.404E-05	0.743	0.733	2.418	3868.5	-5.394	3.120
1340.5	5.094	1.129	0.494E-05	0.755	0.746	2.457	3892.0	-5.306	3.127
1364.5	5.090	1.137	0.241E-05	0.760	0.745	2.471	3916.0	-5.617	3.135
1388.5	5.185	1.147	0.268E-05	0.767	0.759	2.498	3940.0	-5.575	3.143
1413.0	5.180	1.160	0.355E-05	0.775	0.759	2.519	3964.5	-5.449	3.150
1438.5	5.226	1.168	0.228E-05	0.781	0.765	2.539	3990.0	-5.642	3.158
1462.0	5.270	1.180	0.348E-05	0.789	0.772	2.564	4013.5	-5.461	3.165
1484.5	5.317	1.187	0.207E-05	0.794	0.779	2.581	4036.0	-5.885	3.172
1508.5	5.361	1.202	0.411E-05	0.804	0.785	2.810	4060.0	-5.386	3.179
1538.5	5.407	1.211	0.194E-05	0.810	0.792	2.630	4090.0	-5.713	3.187
1556.5	5.405	1.215	0.162E-05	0.813	0.791	2.637	4108.0	-5.792	3.192
1584.5	5.451	1.224	0.207E-05	0.818	0.798	2.656	4136.0	-5.683	3.200
1606.5	5.447	1.232	0.264E-05	0.824	0.798	2.670	4158.0	-5.579	3.206
1652.5	5.543	1.241	0.128E-05	0.830	0.812	2.696	4204.0	-5.898	3.218
1676.5	5.542	1.243	0.483E-06	0.831	0.812	2.699	4228.0	-6.316	3.224
1700.5	5.638	1.252	0.266E-05	0.838	0.826	2.726	4252.0	-5.574	3.231
1725.0	5.489	1.251	-0.238E-06	0.837	0.804	2.706	4276.5	0.0	0.0
1748.0	5.637	1.255	0.969E-06	0.839	0.825	2.730	4300.5	-6.014	3.243

LOAD INCREMENT #13 S.D.= 180 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	5.638	1.253	0.838E+00	0.838	0.825	2.726	4300.5	-0.077	-2.000
1.0	5.634	1.262	0.645E-04	0.844	0.825	2.741	4301.5	-4.191	0.0
4.0	5.631	1.268	0.155E-04	0.849	0.824	2.753	4304.5	-4.809	0.602
8.0	5.629	1.273	0.583E-05	0.851	0.824	2.758	4308.5	-5.234	0.903
23.0	5.667	1.299	0.116E-04	0.869	0.830	2.805	4323.5	-4.935	1.362
46.5	5.710	1.316	0.495E-05	0.880	0.836	2.839	4347.0	-5.306	1.667
69.5	5.704	1.328	0.353E-05	0.888	0.835	2.858	4370.0	-5.452	1.842
93.0	5.751	1.336	0.223E-05	0.894	0.842	2.876	4393.5	-5.652	1.968
117.5	5.746	1.347	0.308E-05	0.901	0.841	2.894	4418.0	-5.511	2.070
141.5	5.781	1.357	0.291E-05	0.908	0.848	2.917	4442.0	-5.537	2.151
165.0	5.836	1.368	0.297E-05	0.915	0.854	2.939	4465.5	-5.528	2.217
188.0	5.881	1.380	0.247E-05	0.923	0.861	2.965	4488.5	-5.808	2.297
215.0	5.875	1.392	0.479E-05	0.931	0.860	2.984	4515.5	-5.320	2.332
237.5	5.872	1.399	0.207E-05	0.936	0.860	2.995	4538.0	-5.685	2.376
261.0	5.918	1.407	0.247E-05	0.942	0.866	3.015	4561.5	-5.807	2.417
285.0	5.965	1.414	0.194E-05	0.947	0.873	3.032	4585.5	-5.713	2.455
309.0	6.060	1.427	0.339E-05	0.955	0.887	3.063	4609.5	-5.469	2.490
333.0	6.054	1.439	0.363E-05	0.963	0.886	3.083	4633.5	-5.440	2.522
358.0	6.098	1.454	0.380E-05	0.973	0.892	3.113	4658.5	-5.420	2.555
383.0	6.143	1.465	0.291E-05	0.980	0.899	3.135	4683.5	-5.536	2.583
407.0	6.187	1.478	0.388E-05	0.990	0.902	3.161	4707.5	-5.411	2.610
429.0	6.233	1.487	0.264E-05	0.995	0.912	3.183	4729.5	-5.578	2.632
453.0	6.277	1.501	0.388E-05	1.005	0.919	3.211	4753.5	-5.411	2.656
477.0	6.321	1.513	0.340E-05	1.013	0.925	3.236	4777.5	-5.469	2.679
501.0	6.317	1.522	0.242E-05	1.019	0.924	3.250	4801.5	-5.618	2.700
527.0	6.312	1.534	0.313E-05	1.027	0.924	3.269	4827.5	-5.504	2.722
552.0	6.339	1.541	0.186E-05	1.032	0.928	3.284	4852.5	-5.728	2.742
573.0	6.402	1.555	0.471E-05	1.041	0.937	3.316	4873.5	-5.327	2.758
597.0	6.448	1.565	0.267E-05	1.048	0.943	3.337	4897.5	-5.674	2.776
621.0	6.491	1.580	0.412E-05	1.058	0.950	3.366	4921.5	-5.385	2.793
645.0	6.487	1.590	0.291E-05	1.065	0.949	3.383	4945.5	-5.636	2.810
669.0	7.013	3.537	0.550E-03	2.384	1.026	6.677	4969.5	-3.260	2.825
675.0	1.867	3.417	-0.136E-03	2.303	0.289	5.876	4975.5	-5.443	2.910
695.0	4.229	3.502	0.289E-04	2.360	0.620	6.288	4995.5	-4.539	2.842
719.5	4.224	3.513	0.289E-05	2.367	0.619	6.304	5020.0	-5.540	2.857
741.0	4.219	3.523	0.329E-05	2.375	0.618	6.321	5041.5	-5.482	2.870
772.0	4.117	3.529	0.133E-05	2.379	0.603	6.319	5072.5	-5.876	2.888
789.0	4.167	3.528	-0.348E-06	2.378	0.611	6.324	5089.5	-5.900	2.981
813.0	4.215	3.532	0.984E-06	2.380	0.616	6.335	5113.5	-6.007	2.910
837.0	4.312	3.539	0.196E-05	2.385	0.632	6.358	5137.5	-5.707	2.923
888.0	4.306	3.552	0.174E-05	2.394	0.631	6.379	5188.5	-5.780	2.948
908.5	4.308	3.549	-0.863E-06	2.392	0.631	6.375	5209.0	-5.772	3.022
933.5	4.306	3.552	0.708E-06	2.394	0.631	6.379	5234.0	-6.150	2.970
957.0	4.307	3.551	-0.252E-06	2.393	0.631	6.378	5257.5	-5.555	3.042
981.0	4.307	3.551	0.0	2.393	0.631	6.378	5281.5	-5.675	3.051
1005.0	4.307	3.550	-0.247E-06	2.393	0.631	6.377	5305.5	-5.790	3.060
1056.0	4.355	3.555	0.894E-06	2.396	0.638	6.391	5356.5	-6.158	3.024
1080.0	4.356	3.552	-0.982E-06	2.394	0.638	6.385	5380.5	-6.838	3.078
1101.0	4.405	3.556	0.140E-05	2.397	0.645	6.398	5401.5	-5.853	3.042
1125.0	4.454	3.568	0.488E-06	2.398	0.653	6.407	5425.5	-6.311	3.051
1149.0	4.452	3.561	0.985E-06	2.400	0.652	6.413	5449.5	-6.007	3.080
1173.0	4.451	3.563	0.491E-06	2.402	0.652	6.415	5473.5	-6.309	3.069
1208.5	4.489	3.568	0.100E-05	2.405	0.659	6.430	5508.0	-6.000	3.082
1245.0	4.500	3.566	-0.326E-06	2.404	0.659	6.427	5545.5	-5.306	3.127
1293.0	4.599	3.567	0.124E-06	2.405	0.674	6.440	5593.5	-6.908	3.112

LOAD INCREMENT #14 S.D.= 196 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	4.600	3.585	0.240E+01	2.403	0.674	6.437	5593.5	0.381	-2.000
1.5	4.550	3.567	0.780E-05	2.404	0.667	6.434	5595.0	-5.102	0.176
8.5	4.498	3.574	0.675E-05	2.409	0.659	6.439	5602.0	-5.171	0.929
23.5	-6.603	3.573	-0.395E-06	2.409	-0.978	5.103	5617.0	-5.234	0.903
47.5	4.545	3.577	0.123E-05	2.412	0.666	6.451	5641.0	-5.911	1.677
97.5	4.593	3.582	0.591E-06	2.414	0.673	6.464	5691.0	-6.228	1.988
119.5	4.691	3.586	0.134E-05	2.417	0.667	6.483	5713.0	-5.873	2.077
146.5	4.638	3.593	0.175E-05	2.422	0.678	6.488	5740.0	-5.757	2.166
167.5	4.689	3.591	-0.564E-06	2.421	0.667	6.491	5761.0	-5.511	2.070
191.5	4.689	3.591	0.0	2.421	0.667	6.491	5785.0	-5.537	2.151
215.0	4.690	3.588	-0.754E-06	2.419	0.667	6.487	5808.5	-5.528	2.217
244.5	4.738	3.592	0.801E-06	2.422	0.694	6.498	5838.0	-5.096	2.388
268.5	4.788	3.594	0.491E-06	2.423	0.701	6.507	5862.0	-6.308	2.429
287.5	4.738	3.594	0.0	2.423	0.694	6.501	5881.0	-5.885	2.376
311.5	4.838	3.594	0.0	2.423	0.709	6.513	5905.0	-5.807	2.417
335.5	4.836	3.598	0.738E-06	2.425	0.708	6.517	5929.0	-6.132	2.526
359.5	4.884	3.601	0.123E-05	2.427	0.716	6.530	5953.0	-5.910	2.556
383.5	4.884	3.602	0.491E-06	2.428	0.715	6.533	5977.0	-6.309	2.584
432.5	4.913	3.603	0.121E-06	2.429	0.720	6.538	6026.0	-6.818	2.638
455.5	4.931	3.607	0.128E-05	2.432	0.722	6.547	6049.0	-5.893	2.658
479.5	4.980	3.610	0.738E-06	2.434	0.729	6.558	6073.0	-6.132	2.681
503.5	4.979	3.612	0.491E-06	2.435	0.729	6.560	6097.0	-6.309	2.702
527.5	4.978	3.620	0.245E-05	2.441	0.729	6.574	6121.0	-5.809	2.722
551.5	4.976	3.619	-0.491E-06	2.440	0.729	6.572	6145.0	-5.469	2.679
804.0	5.025	3.621	0.337E-06	2.442	0.736	6.582	6197.5	-6.472	2.781
623.5	5.024	3.623	0.604E-06	2.443	0.736	6.584	6217.0	-6.219	2.795
647.5	5.173	3.626	0.738E-06	2.445	0.758	6.607	6241.0	-6.133	2.811
671.0	5.250	3.632	0.176E-05	2.449	0.769	6.626	6264.5	-5.755	2.827
695.5	5.249	3.636	0.121E-05	2.452	0.769	6.633	6289.0	-5.917	2.842
719.5	5.267	3.639	0.736E-06	2.453	0.771	6.639	6313.0	-6.133	2.857

LOAD INCREMENT #15 S.D.= 229 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	5.289	3.635	0.245E+01	2.451	0.772	5.634	6313.0	0.389	-2.000
1.0	5.217	3.640	0.299E-04	2.454	0.764	5.635	6314.0	-4.525	0.0
3.0	5.215	3.644	0.147E-04	2.457	0.764	5.642	6316.0	-4.831	0.477
9.0	5.261	3.652	0.885E-05	2.462	0.771	5.661	6322.0	-5.053	0.954
19.0	5.303	3.670	0.124E-04	2.475	0.777	5.696	6332.0	-4.807	1.279
29.5	5.300	3.677	0.231E-05	2.480	0.776	5.707	6352.5	-5.636	1.597
83.0	5.346	3.685	0.251E-05	2.485	0.783	5.727	6376.0	-5.800	1.799
87.0	5.341	3.698	0.344E-05	2.494	0.782	5.747	6400.0	-5.483	1.940
111.0	5.437	3.706	0.246E-05	2.500	0.796	5.773	6424.0	-5.809	2.045
135.0	5.434	3.713	0.197E-05	2.504	0.796	5.784	6448.0	-5.705	2.130
153.0	5.480	3.721	0.295E-05	2.510	0.802	5.803	6466.0	-5.530	2.185
209.5	5.525	3.733	0.146E-05	2.518	0.809	5.828	6522.5	-5.835	2.321
231.0	5.621	3.741	0.247E-05	2.523	0.823	5.853	6544.0	-5.807	2.364
255.0	5.667	3.751	0.295E-05	2.530	0.830	5.875	6568.0	-5.529	2.407
279.0	5.714	3.758	0.197E-05	2.535	0.836	5.883	6592.0	-5.705	2.446
303.0	5.762	3.762	0.986E-06	2.537	0.844	5.904	6616.0	-6.006	2.481
327.0	5.758	3.771	0.271E-05	2.544	0.843	5.920	6640.0	-5.568	2.515
351.0	5.806	3.775	0.123E-05	2.547	0.850	5.933	6664.0	-5.909	2.545
377.5	5.802	3.784	0.223E-05	2.553	0.849	5.947	6690.5	-5.652	2.577
389.0	5.788	3.790	0.193E-05	2.557	0.849	5.956	6712.0	-5.716	2.601
423.0	5.847	3.794	0.123E-05	2.560	0.856	5.969	6736.0	-5.910	2.626
447.0	5.894	3.801	0.197E-05	2.565	0.863	5.987	6760.0	-5.705	2.650
471.0	5.910	3.810	0.248E-05	2.571	0.865	7.003	6784.0	-5.808	2.673
499.0	5.987	3.819	0.211E-05	2.576	0.876	7.026	6812.0	-5.875	2.698
544.5	5.985	3.822	0.518E-06	2.579	0.876	7.032	6857.5	-6.286	2.736
567.0	6.033	3.827	0.158E-05	2.582	0.883	7.046	6880.0	-5.802	2.754
591.0	6.082	3.830	0.739E-06	2.584	0.890	7.057	6904.0	-6.132	2.772
615.0	6.127	3.840	0.296E-05	2.591	0.897	7.079	6928.0	-5.529	2.789
639.0	6.155	3.844	0.981E-06	2.594	0.901	7.088	6952.0	-6.008	2.806
663.0	6.174	3.846	0.739E-06	2.595	0.904	7.095	6976.0	-6.131	2.822
687.0	6.220	3.856	0.271E-05	2.602	0.910	7.116	7000.0	-5.567	2.837
711.0	6.248	3.859	0.984E-06	2.604	0.914	7.126	7024.0	-6.007	2.852
735.0	6.286	3.864	0.123E-05	2.607	0.917	7.135	7048.0	-5.909	2.866
759.0	6.345	3.866	0.739E-06	2.609	0.929	7.149	7072.0	-6.131	2.880
783.0	6.283	3.871	0.148E-05	2.612	0.919	7.150	7096.0	-5.831	2.894
807.0	6.341	3.877	0.148E-05	2.616	0.928	7.166	7120.0	-5.830	2.907

LOAD INCREMENT #16 S.D.= 261 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	6.362	3.874	0.281E+01	2.614	0.931	7.164	7120.0	0.417	-2.000
1.0	6.259	3.879	0.359E-04	2.618	0.916	7.161	7121.0	-4.445	0.0
8.0	6.354	3.892	0.118E-04	2.626	0.930	7.192	7128.0	-4.827	0.903
25.0	6.347	3.907	0.826E-05	2.637	0.929	7.217	7145.0	-5.203	1.398
49.0	6.439	3.925	0.518E-05	2.649	0.942	7.259	7169.0	-5.286	1.690
73.0	6.430	3.944	0.542E-05	2.662	0.941	7.290	7193.0	-5.266	1.863
100.0	6.522	3.962	0.480E-05	2.675	0.954	7.331	7220.0	-5.337	2.000
121.0	6.568	3.972	0.310E-05	2.681	0.961	7.352	7241.0	-5.509	2.083
147.0	6.605	4.000	0.728E-05	2.700	0.966	7.403	7267.0	-5.138	2.167
168.0	6.626	4.000	0.0	2.700	0.969	7.406	7288.0	-5.705	2.130
217.5	6.695	4.022	0.311E-05	2.716	0.979	7.451	7337.5	-5.507	2.337
240.0	6.790	4.033	0.342E-05	2.723	0.993	7.482	7360.0	-5.466	2.380
264.0	6.785	4.045	0.321E-05	2.731	0.993	7.500	7384.0	-5.494	2.422
288.0	6.781	4.054	0.271E-05	2.737	0.992	7.515	7408.0	-5.567	2.459
312.0	6.828	4.061	0.197E-05	2.742	0.999	7.533	7432.0	-5.705	2.494
337.0	6.874	4.070	0.237E-05	2.748	1.006	7.553	7457.0	-5.625	2.528
367.0	6.872	4.075	0.710E-06	2.752	1.005	7.561	7507.0	-6.149	2.588
408.0	6.919	4.082	0.226E-05	2.756	1.012	7.578	7528.0	-5.646	2.611
432.0	6.964	4.091	0.271E-05	2.763	1.019	7.599	7552.0	-5.567	2.635
456.0	6.960	4.100	0.247E-05	2.769	1.018	7.614	7576.0	-5.608	2.659
480.0	7.006	4.109	0.272E-06	2.775	1.025	7.635	7600.0	-5.566	2.681
504.0	7.053	4.116	0.172E-05	2.780	1.032	7.651	7624.0	-5.764	2.702
554.0	7.097	4.129	0.190E-05	2.789	1.038	7.679	7674.0	-5.722	2.744
576.0	7.144	4.136	0.216E-05	2.794	1.045	7.696	7696.0	-5.666	2.760
600.0	7.163	4.140	0.983E-06	2.796	1.048	7.704	7720.0	-6.007	2.778
624.0	7.238	4.148	0.247E-05	2.802	1.059	7.728	7744.0	-5.607	2.795
648.0	7.333	4.160	0.346E-05	2.810	1.072	7.759	7768.0	-5.461	2.812
672.0	7.329	4.169	0.246E-05	2.816	1.072	7.773	7792.0	-5.608	2.827
697.0	7.327	4.175	0.166E-05	2.820	1.071	7.783	7817.0	-5.780	2.843
722.0	7.423	4.182	0.190E-05	2.825	1.085	7.806	7842.0	-5.722	2.859
744.0	7.441	4.188	0.188E-05	2.829	1.088	7.819	7864.0	-5.726	2.872
768.0	7.517	4.196	0.223E-05	2.835	1.099	7.841	7888.0	-5.652	2.885
792.0	7.513	4.206	0.286E-05	2.842	1.098	7.858	7912.0	-5.529	2.899
816.0	7.558	4.217	0.296E-05	2.849	1.105	7.881	7936.0	-5.528	2.912
840.0	7.605	4.224	0.197E-05	2.854	1.112	7.898	7960.0	-5.705	2.924
889.5	7.697	4.240	0.227E-05	2.865	1.125	7.936	8009.5	-5.643	2.949
911.5	7.692	4.251	0.350E-05	2.873	1.125	7.955	8031.5	-5.455	2.960
935.0	7.788	4.262	0.303E-05	2.880	1.138	7.983	8055.0	-5.519	2.971
959.0	7.784	4.270	0.247E-05	2.886	1.138	7.997	8079.0	-5.607	2.982
983.0	7.834	4.270	0.0	2.886	1.145	8.003	8103.0	-5.707	2.993
1007.0	7.779	4.281	0.297E-05	2.893	1.137	8.014	8127.0	-5.528	3.003
1056.0	7.768	4.305	0.338E-05	2.909	1.136	8.054	8175.0	-5.470	3.024
1103.0	7.821	4.298	-0.101E-05	2.905	1.143	8.048	8223.0	-6.150	2.970
1127.0	7.967	4.308	0.296E-05	2.912	1.164	8.083	8247.0	-5.528	3.052
1151.0	8.064	4.315	0.198E-05	2.916	1.179	8.106	8271.0	-5.704	3.061
1180.0	8.058	4.328	0.307E-05	2.925	1.178	8.127	8300.0	-5.513	3.072
1225.0	8.203	4.339	0.158E-05	2.932	1.199	8.162	8345.0	-5.801	3.088
1247.5	8.249	4.348	0.290E-05	2.939	1.205	8.183	8367.5	-5.536	3.096
1271.5	8.244	4.359	0.322E-05	2.947	1.205	8.202	8391.5	-5.483	3.104
1295.5	8.340	4.368	0.247E-05	2.953	1.219	8.227	8415.5	-5.607	3.112
1319.5	8.337	4.375	0.197E-05	2.957	1.218	8.239	8439.5	-5.705	3.120

LOAD INCREMENT #17 S.D.= 294 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	8.338	4.373	0.296E+01	2.956	1.218	8.236	8439.5	0.471	-2.000
1.0	8.336	4.376	0.180E-04	2.958	1.218	8.240	8440.5	-4.745	0.0
2.0	8.335	4.380	0.296E-04	2.961	1.218	8.248	8441.5	-4.529	0.301
8.0	8.328	4.394	0.158E-04	2.971	1.217	8.270	8447.5	-4.800	0.903
27.0	8.418	4.418	0.843E-05	2.987	1.230	8.320	8466.5	-5.074	1.431
50.0	8.513	4.429	0.336E-05	2.994	1.244	8.350	8489.5	-5.474	1.699
72.5	8.503	4.450	0.633E-05	3.009	1.242	8.384	8512.0	-5.198	1.860
95.5	8.592	4.475	0.749E-05	3.026	1.255	8.437	8535.0	-5.126	1.980
119.5	8.632	4.497	0.643E-05	3.041	1.261	8.479	8559.0	-5.192	2.077
143.5	8.676	4.511	0.396E-05	3.051	1.267	8.508	8583.0	-5.402	2.157
167.5	8.671	4.523	0.346E-05	3.059	1.267	8.527	8607.0	-5.461	2.224
191.5	8.761	4.544	0.594E-05	3.073	1.280	8.573	8631.0	-5.226	2.282
216.5	8.854	4.560	0.451E-05	3.085	1.293	8.612	8656.0	-5.345	2.335
240.5	8.651	4.565	0.149E-05	3.088	1.264	8.586	8680.0	-5.826	2.381
263.5	8.841	4.589	0.897E-05	3.104	1.291	8.658	8703.0	-5.157	2.421
287.5	9.032	4.608	0.545E-05	3.117	1.319	8.713	8727.0	-5.264	2.459
311.5	9.172	4.631	0.669E-05	3.133	1.339	8.769	8751.0	-5.175	2.493
335.5	9.213	4.652	0.595E-05	3.148	1.345	8.808	8775.0	-5.226	2.526
359.5	9.203	4.674	0.619E-05	3.162	1.344	8.844	8799.0	-5.206	2.556
455.5	9.377	4.731	0.415E-05	3.202	1.369	8.962	8895.0	-5.382	2.658
479.5	9.471	4.744	0.372E-05	3.211	1.383	8.995	8919.0	-5.430	2.681
503.5	9.465	4.757	0.372E-05	3.220	1.382	9.016	8943.0	-5.429	2.702
527.5	9.412	4.765	0.223E-05	3.225	1.374	9.023	8967.0	-5.652	2.722
575.5	9.458	4.775	0.439E-06	3.232	1.381	9.044	9116.0	-6.357	2.830
601.0	9.406	4.778	-0.316E-06	3.234	1.373	9.044	9040.5	-6.007	2.778
623.5	9.353	4.784	0.185E-05	3.239	1.366	9.048	9063.0	-5.732	2.795
647.5	9.553	4.786	0.493E-06	3.240	1.385	9.074	9087.0	-6.307	2.811
671.5	9.560	4.792	0.174E-05	3.244	1.394	9.084	9111.0	-5.760	2.827
695.5	9.646	4.802	0.234E-05	3.250	1.408	9.112	9139.0	-5.631	2.845
744.5	9.642	4.809	0.119E-05	3.256	1.408	9.124	9184.0	-6.825	2.872
767.6	9.638	4.819	0.284E-05	3.262	1.407	9.140	9207.1	-5.547	2.885
793.5	9.733	4.829	0.276E-05	3.269	1.421	9.169	9233.0	-5.559	2.900
815.5	9.733	4.829	0.0	3.269	1.421	9.169	9255.0	-5.529	2.899
839.5	9.730	4.835	0.174E-05	3.274	1.420	9.178	9279.0	-5.760	2.924
863.5	9.728	4.840	0.149E-05	3.277	1.420	9.187	9303.0	-5.827	2.936
912.5	9.925	4.847	0.850E-06	3.281	1.449	9.221	9352.0	-6.071	2.960
935.5	10.023	4.853	0.181E-05	3.286	1.463	9.242	9375.0	-5.742	2.971
959.5	10.016	4.866	0.397E-05	3.295	1.462	9.265	9399.0	-5.402	2.982

LOAD INCREMENT #18 S.D.= 327 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	10.016	4.867	0.330E+01	3.296	1.462	9.266	9399.0	0.518	-2.000
0.5	10.014	4.872	0.729E-04	3.299	1.462	9.274	9399.5	-4.137	-0.301
2.0	10.010	4.882	0.437E-04	3.306	1.461	9.290	9401.0	-4.360	0.301
7.5	10.006	4.890	0.108E-04	3.312	1.460	9.304	9406.5	-4.866	0.875
23.5	10.095	4.915	0.104E-04	3.328	1.473	9.355	9422.5	-4.982	1.371
33.0	10.091	4.923	0.627E-05	3.334	1.473	9.370	9432.0	-5.203	1.519
47.5	10.134	4.940	0.780E-05	3.346	1.479	9.402	9446.5	-5.108	1.677
75.0	10.267	4.977	0.932E-05	3.371	1.498	9.461	9474.0	-5.031	1.875
120.5	10.344	5.029	0.786E-05	3.407	1.509	9.578	9519.5	-5.105	2.081
143.5	10.432	5.055	0.777E-05	3.425	1.522	9.632	9542.5	-5.109	2.157
167.5	10.518	5.085	0.870E-05	3.446	1.535	9.693	9566.5	-5.061	2.224
191.5	10.509	5.106	0.596E-05	3.460	1.533	9.727	9590.5	-5.225	2.282
215.5	10.648	5.131	0.721E-05	3.477	1.553	9.786	9614.5	-5.142	2.333
240.5	10.684	5.161	0.835E-05	3.498	1.559	9.841	9639.5	-5.078	2.381

GEOTECHNICAL LABORATORIES
DEPARTMENT OF CIVIL ENGINEERING
UNIVERSITY OF MANITOBA

CONSTANT CELL PRESSURE MULTI-STAGE TRIAXIAL CREEP TEST

MST13 – σ_3 = 70 kPa

LOAD INCREMENT # 1 S.D.= 0 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	-2.080	-0.025	-0.188E-01	-0.017	-0.302	0.287	0.0	0.0	0.0
0.5	-2.131	-0.023	0.253E-04	-0.015	-0.312	0.293	0.5	-4.597	-0.301
2.0	-2.216	-0.010	0.578E-04	-0.007	-0.325	0.282	2.0	-4.238	0.301
4.0	-2.266	-0.011	-0.334E-05	-0.007	-0.332	0.289	4.0	0.0	0.0
10.0	-2.317	-0.007	0.413E-05	-0.005	-0.340	0.289	10.0	-5.384	1.000
27.0	-2.421	0.004	0.432E-05	0.002	-0.355	0.284	27.0	-5.368	1.431
47.5	-2.542	0.005	0.287E-06	0.003	-0.373	0.297	47.5	-6.528	1.677
71.5	-2.622	0.005	0.0	0.003	-0.384	0.306	71.5	0.0	0.0
95.5	-2.672	0.005	0.0	0.003	-0.392	0.312	95.5	0.0	0.0
121.0	-2.723	0.006	0.484E-06	0.004	-0.399	0.316	121.0	-6.315	2.083
148.5	-2.723	0.006	0.0	0.004	-0.398	0.315	148.5	0.0	0.0
167.5	-2.723	0.006	0.0	0.004	-0.399	0.315	167.5	0.0	0.0
191.5	-2.773	0.006	0.0	0.004	-0.407	0.321	191.5	0.0	0.0
215.0	-2.823	0.007	0.264E-06	0.005	-0.414	0.326	215.0	-6.579	2.332
239.0	-2.873	0.006	-0.258E-06	0.004	-0.421	0.333	239.0	0.0	0.0
263.0	-2.923	0.005	0.0	0.004	-0.429	0.339	263.0	0.0	0.0
289.0	-2.942	0.006	-0.236E-06	0.004	-0.432	0.343	289.0	0.0	0.0
315.0	-2.923	0.006	0.236E-06	0.004	-0.429	0.339	315.0	-6.627	2.498
335.5	-2.923	0.006	0.0	0.004	-0.429	0.339	335.5	0.0	0.0

LOAD INCREMENT # 2 S.D.= 85 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	-0.004	0.011	0.763E-02	0.008	-0.001	0.018	0.0	-2.117	-2.000
0.5	-0.089	0.023	0.151E-03	0.015	-0.013	0.026	0.5	-3.821	-0.301
2.0	-0.119	0.048	0.115E-03	0.032	-0.017	0.065	2.0	-3.940	0.301
4.5	-0.121	0.055	0.173E-04	0.037	-0.018	0.075	4.5	-4.763	0.653
7.0	-0.123	0.059	0.123E-04	0.040	-0.018	0.082	7.0	-4.910	0.845
23.0	-0.152	0.082	0.924E-05	0.054	-0.022	0.115	23.0	-5.035	1.362
74.0	-0.165	0.116	0.447E-05	0.077	-0.024	0.169	74.0	-5.350	1.869
121.0	-0.241	0.107	-0.131E-05	0.071	-0.036	0.145	121.0	0.0	0.0
144.5	-0.243	0.111	0.131E-05	0.074	-0.036	0.152	144.5	-5.882	2.180
171.5	-0.245	0.117	0.137E-05	0.078	-0.036	0.161	171.5	-5.863	2.234
218.0	-0.248	0.123	0.925E-06	0.082	-0.036	0.171	218.0	-6.034	2.338
243.5	-0.248	0.122	-0.239E-06	0.082	-0.036	0.170	243.5	0.0	0.0
270.0	-0.248	0.122	0.0	0.082	-0.036	0.170	270.0	0.0	0.0
289.5	-0.249	0.125	0.948E-06	0.083	-0.037	0.174	289.5	-6.023	2.462
312.5	-0.249	0.127	0.537E-06	0.085	-0.037	0.177	312.5	-6.270	2.495

LOAD INCREMENT # 3 S.D.= 82 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	-0.248	0.125	0.831E-01	0.083	-0.037	0.174	312.5	-1.080	-2.000
0.5	-0.347	0.122	-0.377E-04	0.081	-0.051	0.167	313.0	-3.821	-0.301
2.0	-0.351	0.132	0.451E-04	0.088	-0.052	0.173	314.5	-4.345	0.301
4.0	-0.301	0.131	-0.304E-05	0.087	-0.044	0.178	316.5	-4.763	0.863
6.5	-0.301	0.132	0.243E-05	0.088	-0.044	0.179	319.0	-5.614	0.813
23.0	-0.355	0.142	0.411E-05	0.095	-0.052	0.189	335.5	-5.386	1.362
47.0	-0.360	0.153	0.308E-05	0.102	-0.053	0.207	359.5	-5.511	1.672
71.5	-0.362	0.159	0.151E-05	0.106	-0.053	0.216	384.0	-5.822	1.854
95.0	-0.365	0.167	0.236E-05	0.111	-0.054	0.229	407.5	-5.627	1.978
126.5	-0.389	0.176	0.196E-05	0.118	-0.057	0.241	439.0	-5.708	2.102
145.0	-0.371	0.182	0.200E-05	0.121	-0.055	0.253	457.5	-5.899	2.161
167.0	-0.371	0.184	0.559E-06	0.123	-0.055	0.255	479.5	-6.253	2.223

LOAD INCREMENT # 4 S.D.= 98 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	-0.371	0.183	0.122E+00	0.122	-0.055	0.254	479.5	-0.915	-2.000
0.5	-0.371	0.183	0.0	0.122	-0.055	0.254	480.0	-3.821	-0.301
2.0	-0.374	0.189	0.288E-04	0.126	-0.055	0.264	481.5	-4.541	0.301
4.0	-0.375	0.193	0.123E-04	0.129	-0.055	0.270	483.5	-4.909	0.602
6.5	-0.374	0.191	-0.494E-05	0.127	-0.055	0.267	486.0	-5.614	0.813
23.0	-0.380	0.206	0.598E-05	0.137	-0.056	0.290	502.5	-5.223	1.362
47.0	-0.384	0.215	0.257E-05	0.143	-0.056	0.305	526.5	-5.591	1.672
71.0	-0.387	0.224	0.257E-05	0.149	-0.057	0.320	550.5	-5.590	1.851
95.0	-0.389	0.228	0.128E-05	0.153	-0.057	0.327	574.5	-5.892	1.978
122.0	-0.344	0.241	0.297E-05	0.161	-0.051	0.352	601.5	-5.527	2.086
151.0	-0.393	0.240	-0.214E-06	0.160	-0.058	0.345	630.5	-5.699	2.161
167.0	-0.394	0.241	0.388E-06	0.161	-0.058	0.346	646.5	-6.411	2.223
191.0	-0.385	0.244	0.766E-06	0.162	-0.058	0.350	670.5	-6.116	2.281
215.0	-0.445	0.245	0.517E-06	0.164	-0.066	0.347	694.5	-6.286	2.332
239.0	-0.477	0.249	0.103E-05	0.166	-0.070	0.350	718.5	-5.988	2.378
263.0	-0.477	0.250	0.254E-06	0.167	-0.070	0.351	742.5	-6.596	2.420
288.5	-0.448	0.253	0.728E-06	0.169	-0.066	0.359	768.0	-6.138	2.460
312.5	-0.450	0.257	0.129E-05	0.172	-0.066	0.366	792.0	-5.891	2.495
335.0	-0.401	0.259	0.547E-06	0.173	-0.059	0.375	814.5	-6.262	2.525

LOAD INCREMENT # 5 S.D.= 114 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	-0.449	0.255	0.170E+00	0.170	-0.086	0.363	814.5	-0.769	-2.000
0.5	-0.469	0.255	0.0	0.170	-0.069	0.361	815.0	-3.821	-0.301
2.5	-0.452	0.262	0.216E-04	0.175	-0.066	0.373	817.0	-4.666	0.398
4.5	-0.401	0.280	-0.621E-05	0.173	-0.058	0.376	819.0	-4.909	0.802
7.5	-0.401	0.259	-0.203E-05	0.173	-0.059	0.376	822.0	-5.614	0.813
23.5	-0.403	0.265	0.270E-05	0.177	-0.059	0.385	838.0	-5.568	1.371
47.5	-0.427	0.276	0.283E-05	0.184	-0.063	0.398	862.0	-5.648	1.677
71.5	-0.459	0.280	0.128E-05	0.187	-0.067	0.403	886.0	-5.891	1.854
103.5	-0.463	0.290	0.212E-05	0.194	-0.068	0.419	918.0	-5.674	2.015
121.0	-0.414	0.294	0.141E-05	0.196	-0.061	0.431	935.5	-5.852	2.083
143.5	-0.416	0.298	0.137E-05	0.199	-0.061	0.438	958.0	-5.863	2.157
167.5	-0.416	0.298	0.0	0.199	-0.061	0.438	982.0	-6.411	2.223
191.5	-0.419	0.307	0.231E-05	0.205	-0.062	0.451	1006.0	-5.636	2.282
215.5	-0.473	0.317	0.282E-05	0.212	-0.070	0.461	1030.0	-5.549	2.333
242.5	-0.444	0.320	0.688E-06	0.213	-0.065	0.469	1057.0	-6.162	2.385
289.5	-0.525	0.323	0.383E-06	0.215	-0.077	0.464	1104.0	-6.406	2.462
311.5	-0.527	0.326	0.842E-06	0.217	-0.077	0.469	1126.0	-6.075	2.493
336.5	-0.527	0.326	0.0	0.217	-0.077	0.469	1151.0	-5.891	2.485
359.5	-0.528	0.328	0.805E-06	0.219	-0.078	0.473	1174.0	-6.094	2.556
383.5	-0.528	0.331	0.769E-06	0.221	-0.078	0.477	1198.0	-6.114	2.584
410.5	-0.529	0.333	0.456E-06	0.222	-0.078	0.480	1225.0	-6.341	2.613
457.0	-0.429	0.333	0.0	0.222	-0.063	0.492	1271.5	0.0	0.0
484.5	-0.381	0.338	0.112E-05	0.225	-0.056	0.506	1299.0	-5.950	2.685
503.5	-0.431	0.338	0.0	0.225	-0.063	0.500	1318.0	0.0	0.0

LOAD INCREMENT # 6 S.D.= 130 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	-0.431	0.336	0.224E+00	0.224	-0.063	0.498	1318.0	-0.649	-2.000
0.5	-0.450	0.335	-0.127E-04	0.224	-0.066	0.494	1318.5	-3.821	-0.301
3.5	-0.433	0.343	0.165E-04	0.229	-0.064	0.508	1321.5	-4.783	0.544
8.5	-0.388	0.354	0.148E-04	0.236	-0.057	0.532	1326.5	-4.830	0.929
23.5	-0.388	0.354	0.0	0.236	-0.057	0.532	1341.5	-5.614	0.813
47.5	-0.440	0.359	0.154E-05	0.240	-0.065	0.535	1365.5	-5.812	1.677
71.5	-0.382	0.366	0.180E-05	0.244	-0.058	0.551	1389.5	-5.745	1.854
121.0	-0.448	0.380	0.187E-05	0.253	-0.066	0.567	1439.0	-5.728	2.083
143.5	-0.449	0.384	0.137E-05	0.256	-0.066	0.574	1461.5	-5.862	2.157
167.5	-0.453	0.394	0.257E-05	0.263	-0.067	0.589	1485.5	-5.590	2.224
191.5	-0.455	0.399	0.155E-05	0.266	-0.067	0.598	1509.5	-5.811	2.282
215.5	-0.458	0.406	0.180E-05	0.271	-0.067	0.608	1533.5	-5.746	2.333
239.5	-0.410	0.411	0.155E-05	0.274	-0.080	0.623	1557.5	-5.811	2.379
289.0	-0.463	0.420	0.125E-05	0.281	-0.068	0.632	1607.0	-5.904	2.461
311.5	-0.465	0.425	0.137E-05	0.284	-0.068	0.639	1629.5	-5.862	2.493
335.5	-0.367	0.429	0.103E-05	0.286	-0.054	0.657	1653.5	-5.989	2.526
359.5	-0.467	0.431	0.516E-06	0.287	-0.069	0.648	1677.5	-6.288	2.556
383.5	-0.519	0.433	0.772E-06	0.289	-0.076	0.646	1701.5	-6.112	2.584
407.5	-0.469	0.434	0.259E-06	0.290	-0.084	0.642	1725.5	-6.587	2.610
455.5	-0.519	0.434	0.0	0.290	-0.076	0.648	1773.5	-6.114	2.584
479.5	-0.519	0.433	-0.259E-06	0.289	-0.076	0.646	1797.5	-6.341	2.613
503.5	-0.471	0.440	0.180E-05	0.294	-0.089	0.662	1821.5	-5.745	2.702
527.5	-0.375	0.449	0.258E-05	0.300	-0.055	0.689	1845.5	-5.589	2.722
551.5	-0.377	0.455	0.154E-05	0.303	-0.055	0.698	1869.5	-5.812	2.742
575.5	-0.378	0.458	0.103E-05	0.306	-0.056	0.704	1893.5	-5.988	2.760
608.5	-0.331	0.465	0.131E-05	0.310	-0.049	0.720	1926.5	-5.883	2.784
647.5	-0.284	0.473	0.142E-05	0.316	-0.042	0.739	1965.5	-5.846	2.811
671.5	-0.286	0.478	0.129E-05	0.319	-0.042	0.747	1989.5	-5.890	2.827
695.5	-0.287	0.481	0.103E-05	0.321	-0.042	0.752	2013.5	-5.988	2.842
719.5	-0.289	0.485	0.103E-05	0.324	-0.042	0.758	2037.5	-5.988	2.857
746.5	-0.339	0.486	0.230E-06	0.324	-0.050	0.754	2084.5	-6.638	2.873
786.0	-0.291	0.492	0.748E-06	0.328	-0.043	0.769	2114.0	-6.126	2.901
818.5	-0.294	0.499	0.220E-05	0.333	-0.043	0.780	2136.5	-5.658	2.913
842.5	-0.298	0.508	0.257E-05	0.339	-0.044	0.795	2160.5	-5.590	2.926
866.5	-0.299	0.511	0.773E-06	0.341	-0.044	0.800	2184.5	-6.112	2.938
890.5	-0.299	0.513	0.513E-06	0.342	-0.044	0.802	2208.5	-6.290	2.950
922.5	-0.301	0.518	0.966E-06	0.345	-0.044	0.810	2240.5	-6.015	2.965
964.0	-0.303	0.522	0.742E-06	0.348	-0.045	0.817	2282.0	-6.129	2.984
986.5	-0.254	0.524	0.553E-06	0.350	-0.037	0.826	2304.5	-6.257	2.994
1010.5	-0.155	0.527	0.770E-06	0.352	-0.023	0.843	2328.5	-6.113	3.005
1034.5	-0.208	0.534	0.206E-05	0.356	-0.031	0.848	2352.5	-5.686	3.015
1058.5	-0.208	0.536	0.516E-06	0.358	-0.031	0.851	2376.5	-6.287	3.025
1082.5	-0.259	0.538	0.513E-06	0.359	-0.038	0.848	2400.5	-6.290	3.034

LOAD INCREMENT # 7 S.D.= 147 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	-0.259	0.537	0.358E+00	0.358	-0.038	0.846	2400.5	-0.446	-2.000
1.0	-0.258	0.536	-0.124E-04	0.357	-0.038	0.844	2401.5	-3.821	-0.301
3.0	-0.260	0.540	0.185E-04	0.361	-0.038	0.852	2403.5	-4.732	0.477
9.0	-0.214	0.550	0.103E-04	0.367	-0.031	0.873	2409.5	-4.988	0.954
25.0	-0.215	0.552	0.118E-05	0.369	-0.032	0.877	2425.5	-5.934	1.398
47.0	-0.217	0.557	0.140E-05	0.372	-0.032	0.885	2447.5	-5.853	1.672
72.0	-0.273	0.573	0.420E-05	0.382	-0.040	0.904	2472.5	-5.377	1.857
96.5	-0.325	0.578	0.177E-05	0.387	-0.048	0.908	2497.0	-5.752	1.985
120.0	-0.277	0.584	0.131E-05	0.390	-0.041	0.921	2520.5	-5.881	2.079
147.0	-0.277	0.585	0.228E-06	0.390	-0.041	0.823	2547.5	-6.842	2.167
171.0	-0.186	0.607	0.618E-05	0.405	-0.027	0.870	2571.5	-5.209	2.233
194.0	-0.180	0.615	0.269E-05	0.411	-0.028	0.885	2594.5	-5.571	2.288
217.0	-0.193	0.625	0.288E-05	0.418	-0.028	1.000	2617.5	-5.570	2.336
240.0	-0.197	0.635	0.269E-05	0.424	-0.029	1.014	2640.5	-5.571	2.380
264.0	-0.251	0.647	0.335E-05	0.432	-0.037	1.028	2664.5	-5.475	2.422
288.0	-0.254	0.654	0.206E-05	0.437	-0.037	1.038	2688.5	-5.687	2.459
312.0	-0.256	0.660	0.154E-05	0.440	-0.038	1.048	2712.5	-5.811	2.494
336.5	-0.211	0.672	0.328E-05	0.448	-0.031	1.073	2737.0	-5.484	2.527
362.0	-0.213	0.677	0.145E-05	0.452	-0.031	1.082	2762.5	-5.838	2.559
385.0	-0.166	0.685	0.215E-05	0.457	-0.024	1.100	2785.5	-5.668	2.585
408.0	-0.169	0.691	0.188E-05	0.461	-0.025	1.110	2808.5	-5.725	2.611
432.0	-0.142	0.700	0.258E-05	0.468	-0.021	1.128	2832.5	-5.589	2.635
462.0	-0.143	0.703	0.517E-06	0.470	-0.021	1.133	2862.5	-6.210	2.665
480.0	-0.124	0.705	0.692E-06	0.471	-0.018	1.138	2880.5	-6.160	2.681
506.0	-0.078	0.716	0.265E-05	0.478	-0.012	1.162	2906.5	-5.577	2.706
530.0	-0.080	0.720	0.112E-05	0.481	-0.012	1.168	2930.5	-5.949	2.724
552.0	-0.083	0.728	0.253E-05	0.486	-0.012	1.181	2952.5	-5.597	2.742
576.0	-0.034	0.731	0.774E-06	0.488	-0.005	1.191	2976.5	-6.111	2.760
600.0	-0.037	0.738	0.206E-05	0.493	-0.005	1.203	3000.5	-5.685	2.778
624.5	-0.187	0.738	0.0	0.493	-0.027	1.185	3025.0	-5.988	2.857
648.5	-0.041	0.747	0.258E-05	0.499	-0.006	1.218	3049.0	-5.589	2.812
674.0	-0.042	0.752	0.121E-05	0.502	-0.006	1.225	3074.5	-5.916	2.829
697.5	-0.044	0.756	0.105E-05	0.505	-0.006	1.231	3098.0	-5.978	2.844
720.5	-0.045	0.758	0.536E-06	0.506	-0.007	1.234	3121.0	-6.270	2.858

LOAD INCREMENT # 8 S.D.= 163 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	-0.044	0.755	0.505E+00	0.505	-0.006	1.231	3121.0	-0.297	-2.000
1.0	-0.044	0.757	0.125E-04	0.506	-0.007	1.234	3122.0	-4.904	0.0
4.5	-0.095	0.759	0.354E-05	0.507	-0.014	1.231	3125.5	-5.451	0.653
8.5	-0.095	0.759	0.0	0.507	-0.014	1.231	3129.5	-4.988	0.954
23.5	-0.047	0.764	0.206E-05	0.510	-0.007	1.244	3144.5	-5.685	1.371
46.0	-0.052	0.776	0.328E-05	0.518	-0.008	1.263	3169.0	-5.484	1.681
72.0	-0.056	0.787	0.310E-05	0.526	-0.008	1.281	3193.0	-5.509	1.857
95.5	-0.059	0.794	0.210E-05	0.531	-0.009	1.293	3216.5	-5.677	1.980
128.5	-0.013	0.805	0.225E-05	0.538	-0.002	1.316	3249.5	-5.648	2.109
145.5	-0.016	0.813	0.282E-05	0.543	-0.002	1.328	3266.5	-5.535	2.163
168.0	-0.018	0.818	0.165E-05	0.547	-0.003	1.337	3289.0	-5.783	2.225
191.5	-0.020	0.824	0.158E-05	0.550	-0.003	1.346	3312.5	-5.801	2.282
215.5	0.028	0.829	0.155E-05	0.554	0.004	1.361	3336.5	-5.810	2.333
239.5	0.074	0.839	0.258E-05	0.560	0.011	1.381	3360.5	-5.589	2.379
263.5	0.072	0.843	0.129E-05	0.563	0.011	1.389	3384.5	-5.889	2.421
289.5	0.067	0.856	0.333E-05	0.572	0.010	1.409	3410.5	-5.477	2.462
313.5	0.065	0.863	0.181E-05	0.576	0.009	1.420	3434.5	-5.743	2.496
337.5	0.059	0.877	0.413E-05	0.586	0.008	1.443	3458.5	-5.384	2.528
359.5	0.056	0.885	0.225E-05	0.591	0.008	1.455	3480.5	-5.648	2.556
383.5	0.052	0.894	0.258E-05	0.597	0.008	1.470	3504.5	-5.588	2.584
407.5	0.048	0.902	0.232E-05	0.603	0.007	1.483	3528.5	-5.634	2.610
431.5	0.046	0.911	0.232E-05	0.609	0.007	1.496	3552.5	-5.634	2.635
457.5	0.044	0.914	0.853E-06	0.611	0.006	1.502	3578.5	-6.021	2.660
482.5	0.072	0.920	0.148E-05	0.615	0.011	1.515	3603.5	-5.828	2.683
503.5	0.138	0.930	0.324E-05	0.622	0.020	1.539	3624.5	-5.489	2.702
527.5	0.137	0.933	0.775E-06	0.623	0.020	1.544	3648.5	-6.111	2.722
551.5	0.134	0.940	0.206E-05	0.628	0.020	1.555	3672.5	-5.685	2.742
575.5	0.132	0.947	0.181E-05	0.633	0.019	1.566	3696.5	-5.743	2.760
598.5	7.002	2.052	0.310E-03	1.376	1.024	4.208	3720.5	-3.509	2.778
605.5	1.476	1.992	-0.676E-04	1.336	0.217	3.449	3726.5	-5.988	2.857
626.0	2.689	2.343	0.116E-03	1.573	0.394	4.176	3747.0	-3.936	2.787
650.0	2.678	2.373	0.834E-05	1.593	0.393	4.223	3771.0	-5.079	2.813
671.5	2.671	2.388	0.494E-05	1.604	0.392	4.249	3792.5	-5.306	2.827
695.5	2.668	2.397	0.261E-05	1.610	0.377	4.252	3816.5	-5.583	2.842
719.5	2.665	2.405	0.208E-05	1.615	0.384	4.270	3840.5	-5.681	2.857
743.5	2.664	2.409	0.104E-05	1.618	0.391	4.281	3864.5	-5.982	2.871
767.5	2.709	2.420	0.313E-05	1.625	0.397	4.305	3888.5	-5.504	2.885
818.5	2.752	2.437	0.233E-05	1.637	0.404	4.340	3939.5	-5.632	2.913
839.0	2.750	2.443	0.183E-05	1.641	0.403	4.349	3960.0	-5.738	2.924
863.5	2.748	2.448	0.153E-05	1.645	0.403	4.357	3984.5	-5.815	2.936
887.5	2.747	2.450	0.523E-06	1.646	0.403	4.360	4008.5	-6.282	2.948
911.5	2.747	2.450	0.0	1.646	0.403	4.360	4032.5	-6.287	3.025
935.5	2.747	2.451	0.263E-06	1.646	0.403	4.362	4056.5	-6.581	2.971
986.5	2.744	2.459	0.110E-05	1.652	0.402	4.375	4107.5	-5.957	2.984
1010.5	2.743	2.462	0.783E-06	1.654	0.402	4.380	4131.5	-6.106	3.005
1031.5	2.841	2.467	0.149E-05	1.657	0.417	4.399	4152.5	-5.826	3.013
1055.5	2.839	2.471	0.130E-05	1.660	0.416	4.407	4176.5	-5.886	3.023
1079.5	2.838	2.475	0.105E-05	1.663	0.416	4.413	4200.5	-5.980	3.033
1103.5	2.837	2.478	0.778E-06	1.665	0.416	4.417	4224.5	-6.109	3.043
1139.0	2.934	2.483	0.108E-05	1.668	0.430	4.438	4260.0	-5.975	3.057
1175.5	2.934	2.485	0.345E-06	1.670	0.430	4.441	4296.5	-6.462	3.070
1201.0	2.933	2.487	0.490E-06	1.671	0.430	4.444	4322.0	-6.310	3.080
1223.5	2.932	2.491	0.111E-05	1.673	0.430	4.450	4344.5	-5.954	3.088

LOAD INCREMENT # 9 S.D.= 196 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	2.929	2.497	0.168E+01	1.677	0.430	4.480	4344.5	0.225	-2.000
1.5	2.908	2.500	0.126E-04	1.679	0.427	4.462	4346.0	-4.898	0.176
5.5	2.873	2.514	0.134E-04	1.689	0.421	4.481	4353.0	-4.873	0.929
23.5	2.920	2.522	0.376E-05	1.694	0.428	4.500	4368.0	-5.425	1.371
47.5	2.916	2.532	0.287E-05	1.701	0.428	4.516	4392.0	-5.542	1.677
97.5	3.009	2.549	0.225E-05	1.713	0.441	4.555	4442.0	-5.847	1.988
119.5	3.104	2.562	0.398E-05	1.721	0.455	4.568	4464.0	-5.400	2.077
146.5	3.000	2.572	0.255E-05	1.728	0.440	4.592	4491.0	-5.593	2.166
167.5	3.098	2.576	0.149E-05	1.731	0.454	4.612	4512.0	-5.826	2.224
191.5	3.144	2.587	0.287E-05	1.738	0.461	4.634	4536.0	-5.542	2.282
215.5	3.094	2.587	0.258E-05	1.739	0.454	4.630	4560.0	-5.589	2.333
244.5	3.142	2.592	0.108E-05	1.742	0.461	4.643	4589.0	-5.966	2.388
268.5	3.190	2.597	0.130E-05	1.745	0.468	4.657	4613.0	-5.885	2.429
287.5	3.190	2.598	0.661E-06	1.746	0.468	4.680	4632.0	-6.180	2.459
311.5	3.237	2.605	0.183E-05	1.751	0.475	4.676	4656.0	-5.738	2.493
335.5	3.285	2.611	0.156E-05	1.755	0.482	4.691	4680.0	-5.806	2.526
359.5	3.283	2.615	0.131E-05	1.758	0.481	4.698	4704.0	-5.884	2.556
383.5	3.330	2.623	0.235E-05	1.763	0.488	4.718	4728.0	-5.629	2.584
432.5	3.376	2.633	0.128E-05	1.770	0.495	4.739	4777.0	-5.893	2.636
455.5	3.374	2.639	0.191E-05	1.774	0.495	4.749	4800.0	-5.720	2.658
479.5	3.402	2.645	0.156E-05	1.778	0.499	4.762	4824.0	-5.806	2.681
503.5	3.389	2.651	0.183E-05	1.782	0.498	4.772	4848.0	-5.738	2.702
527.5	3.397	2.656	0.131E-05	1.785	0.498	4.780	4872.0	-5.884	2.722
551.5	3.366	2.659	0.781E-06	1.787	0.494	4.780	4896.0	-6.107	2.742
604.0	3.465	2.663	0.598E-06	1.790	0.508	4.800	4948.5	-6.224	2.781
623.5	3.482	2.670	0.225E-05	1.795	0.507	4.810	4968.0	-5.648	2.795
647.5	3.610	2.676	0.183E-05	1.799	0.529	4.839	4992.0	-5.738	2.811
671.5	3.656	2.685	0.261E-05	1.805	0.536	4.860	5016.0	-5.583	2.827
695.5	3.654	2.690	0.130E-05	1.808	0.536	4.867	5040.0	-5.884	2.842
719.5	3.704	2.690	0.0	1.808	0.543	4.873	5064.0	-5.988	2.857

LOAD INCREMENT #10 S.D.= 229 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	3.700	2.701	0.182E+01	1.816	0.542	4.890	5084.0	0.259	-2.000
1.0	3.648	2.705	0.316E-04	1.819	0.535	4.892	5085.0	-4.500	0.0
3.0	3.647	2.708	0.938E-05	1.821	0.535	4.896	5087.0	-5.028	0.477
9.0	3.642	2.720	0.136E-04	1.829	0.534	4.916	5093.0	-4.867	0.954
19.0	3.733	2.745	0.169E-04	1.846	0.547	4.968	5083.0	-4.771	1.279
39.5	3.805	2.764	0.642E-05	1.859	0.558	5.009	5103.5	-5.193	1.597
63.0	3.818	2.782	0.507E-05	1.871	0.560	5.040	5127.0	-5.295	1.799
87.0	3.830	2.804	0.627E-05	1.886	0.561	5.078	5151.0	-5.203	1.940
111.0	3.904	2.820	0.444E-05	1.897	0.572	5.113	5175.0	-5.352	2.045
135.0	3.998	2.836	0.444E-05	1.907	0.586	5.150	5199.0	-5.352	2.130
153.0	3.991	2.851	0.592E-05	1.918	0.585	5.175	5217.0	-5.227	2.186
209.5	4.082	2.875	0.269E-05	1.934	0.598	5.226	5273.5	-5.539	2.321
231.0	4.157	2.888	0.409E-05	1.943	0.609	5.257	5295.0	-5.388	2.364
255.0	4.151	2.904	0.444E-05	1.954	0.608	5.282	5319.0	-5.352	2.407
279.0	4.266	2.916	0.340E-05	1.962	0.625	5.316	5343.0	-5.489	2.446
303.0	4.262	2.926	0.288E-05	1.969	0.625	5.332	5367.0	-5.541	2.481
327.0	4.277	2.940	0.393E-05	1.978	0.627	5.357	5391.0	-5.406	2.515
351.0	4.284	2.947	0.183E-05	1.983	0.628	5.369	5415.0	-5.737	2.545
377.5	4.349	2.961	0.379E-05	1.993	0.637	5.401	5441.5	-5.421	2.577
399.0	4.444	2.972	0.350E-05	2.000	0.651	5.431	5463.0	-5.456	2.601
423.0	4.490	2.983	0.314E-05	2.008	0.658	5.455	5487.0	-5.503	2.628
447.0	4.515	2.995	0.340E-05	2.016	0.661	5.478	5511.0	-5.468	2.650
471.0	4.531	3.006	0.288E-05	2.023	0.664	5.497	5535.0	-5.541	2.673
499.0	4.577	3.016	0.247E-05	2.030	0.671	5.519	5563.0	-5.608	2.698
544.5	4.672	3.029	0.193E-05	2.038	0.684	5.552	5608.5	-5.714	2.736
567.0	4.719	3.037	0.251E-05	2.044	0.691	5.571	5631.0	-5.600	2.754
591.0	4.715	3.045	0.236E-05	2.050	0.691	5.585	5655.0	-5.628	2.772
615.0	4.712	3.056	0.288E-05	2.057	0.690	5.601	5679.0	-5.541	2.788
663.0	4.726	3.072	0.236E-05	2.068	0.692	5.631	5727.0	-5.628	2.822
687.0	4.800	3.087	0.419E-05	2.078	0.703	5.664	5751.0	-5.378	2.837
711.0	4.897	3.094	0.210E-05	2.083	0.717	5.688	5775.0	-5.678	2.852
735.0	4.994	3.101	0.183E-05	2.087	0.731	5.710	5799.0	-5.737	2.866
759.0	4.992	3.107	0.183E-05	2.092	0.731	5.721	5823.0	-5.737	2.880
783.0	4.939	3.115	0.210E-05	2.097	0.723	5.727	5847.0	-5.678	2.894
807.0	4.936	3.122	0.209E-05	2.102	0.723	5.739	5871.0	-5.679	2.907

LOAD INCREMENT #11 S.D.= 261 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	4.835	3.124	0.210E+01	2.104	0.723	5.743	5871.0	0.323	-2.000
1.0	4.834	3.128	0.254E-04	2.106	0.708	5.737	5872.0	-4.595	0.0
2.0	4.834	3.128	0.0	2.106	0.708	5.737	5873.0	-5.028	0.477
8.0	4.878	3.140	0.136E-04	2.114	0.715	5.762	5879.0	-4.865	0.903
25.0	4.822	3.160	0.778E-05	2.127	0.721	5.800	5896.0	-5.110	1.398
49.0	4.885	3.176	0.472E-05	2.138	0.727	5.833	5920.0	-5.326	1.690
73.0	5.037	3.197	0.576E-05	2.153	0.738	5.875	5944.0	-5.239	1.863
100.0	5.100	3.216	0.490E-05	2.166	0.747	5.915	5971.0	-5.310	2.000
121.0	5.148	3.228	0.329E-05	2.173	0.753	5.937	5992.0	-5.482	2.083
147.0	5.134	3.256	0.774E-05	2.193	0.762	5.985	6018.0	-5.111	2.167
168.0	5.154	3.258	0.598E-06	2.194	0.755	5.991	6039.0	-6.223	2.225
199.0	5.225	3.279	0.467E-05	2.208	0.765	6.035	6070.0	-5.331	2.298
217.5	5.272	3.288	0.340E-05	2.215	0.772	6.056	6088.5	-5.489	2.337
240.0	5.316	3.304	0.478E-05	2.226	0.778	6.087	6111.0	-5.322	2.380
264.0	5.313	3.311	0.210E-05	2.231	0.778	6.099	6135.0	-5.679	2.422
288.0	5.308	3.322	0.315E-05	2.238	0.777	6.117	6159.0	-5.502	2.459
312.0	5.354	3.332	0.289E-05	2.245	0.784	6.139	6183.0	-5.540	2.494
337.0	5.401	3.342	0.252E-05	2.251	0.791	6.160	6208.0	-5.598	2.528
386.0	5.398	3.348	0.800E-06	2.256	0.790	6.171	6257.0	-6.046	2.587
408.0	5.396	3.354	0.172E-05	2.260	0.790	6.180	6278.0	-5.766	2.611
432.0	6.393	3.361	0.210E-05	2.265	0.790	6.192	6303.0	-5.679	2.635
456.0	5.440	3.370	0.263E-05	2.271	0.796	6.213	6327.0	-5.581	2.659
480.0	5.466	3.379	0.262E-05	2.277	0.800	6.231	6351.0	-5.581	2.681
504.0	5.485	3.383	0.105E-05	2.280	0.803	6.240	6375.0	-5.978	2.702
554.0	5.531	3.392	0.126E-05	2.286	0.810	6.261	6425.0	-5.900	2.744
576.0	5.578	3.401	0.258E-05	2.292	0.817	6.280	6447.0	-5.589	2.760
600.0	5.576	3.404	0.105E-05	2.294	0.816	6.286	6471.0	-5.980	2.778
648.0	5.769	3.424	0.276E-05	2.307	0.844	6.342	6519.0	-5.560	2.812
672.0	5.766	3.430	0.184E-05	2.312	0.844	6.352	6543.0	-5.736	2.827
697.0	5.763	3.438	0.201E-05	2.317	0.844	6.364	6568.0	-5.896	2.843
722.0	5.861	3.443	0.152E-05	2.321	0.858	6.385	6593.0	-5.820	2.859
744.0	5.908	3.452	0.286E-05	2.327	0.866	6.406	6615.0	-5.543	2.872
768.0	5.954	3.462	0.263E-05	2.333	0.871	6.427	6639.0	-5.580	2.885
792.0	6.031	3.471	0.263E-05	2.340	0.883	6.451	6663.0	-5.581	2.899
816.0	6.026	3.483	0.341E-05	2.348	0.882	6.471	6687.0	-5.467	2.912
840.0	6.042	3.493	0.289E-05	2.355	0.884	6.490	6711.0	-5.539	2.924
889.0	6.185	3.510	0.232E-05	2.366	0.905	6.535	6760.0	-5.535	2.949
911.5	6.130	3.523	0.392E-05	2.375	0.897	6.550	6782.5	-5.406	2.960
935.0	6.176	3.533	0.295E-05	2.382	0.904	6.572	6806.0	-5.530	2.971
959.0	6.224	3.538	0.158E-05	2.385	0.911	6.587	6830.0	-5.802	2.982
983.0	6.274	3.538	0.0	2.386	0.916	6.593	6854.0	-6.282	2.948
1007.0	6.220	3.550	0.315E-05	2.393	0.910	6.605	6878.0	-5.501	3.003
1056.0	6.112	3.571	0.298E-05	2.408	0.894	6.628	6927.0	-5.529	3.024
1082.0	6.215	3.563	-0.194E-05	2.403	0.909	6.628	6953.0	-5.957	2.994
1103.0	6.362	3.589	0.180E-05	2.406	0.931	6.654	6974.0	-5.745	3.043
1127.0	6.361	3.574	0.132E-05	2.410	0.931	6.662	6998.0	-5.881	3.052
1151.0	6.458	3.579	0.158E-05	2.413	0.945	6.683	7022.0	-5.801	3.061
1180.0	6.455	3.588	0.217E-05	2.420	0.944	6.698	7051.0	-5.663	3.072
1225.0	6.531	3.598	0.140E-05	2.426	0.955	6.722	7096.0	-5.853	3.088
1247.5	6.597	3.609	0.336E-05	2.434	0.965	6.749	7118.5	-5.474	3.098
1271.5	6.592	3.622	0.368E-05	2.442	0.964	6.770	7142.5	-5.434	3.104
1295.5	6.691	3.625	0.105E-05	2.445	0.979	6.788	7166.5	-5.979	3.112
1319.5	6.688	3.631	0.158E-05	2.449	0.978	6.797	7190.5	-5.801	3.120

LOAD INCREMENT #12 S.D.= 327 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	6.686	3.637	0.245E+01	2.453	0.978	6.806	7190.5	0.390	-2.000
1.0	6.589	3.655	0.127E-03	2.465	0.965	6.827	7191.5	-3.895	0.0
2.0	6.576	3.662	0.442E-04	2.470	0.962	6.835	7192.5	-4.355	0.301
8.0	6.665	3.692	0.347E-04	2.491	0.975	6.897	7198.5	-4.460	0.903
27.0	6.689	3.759	0.239E-04	2.536	0.978	7.011	7217.5	-4.621	1.431
50.0	6.821	3.803	0.132E-04	2.566	0.998	7.101	7240.5	-4.880	1.899
72.5	6.903	3.849	0.140E-04	2.598	1.010	7.188	7263.0	-4.853	1.860
95.5	6.887	3.893	0.129E-04	2.628	1.007	7.259	7286.0	-4.889	1.980
119.5	6.973	3.928	0.100E-04	2.652	1.020	7.328	7310.0	-5.000	2.077
143.5	7.062	3.956	0.790E-05	2.671	1.033	7.385	7334.0	-5.102	2.157
167.5	7.052	3.982	0.765E-05	2.689	1.031	7.428	7358.0	-5.117	2.224
191.5	7.140	4.012	0.843E-05	2.709	1.044	7.489	7382.0	-5.074	2.282
216.5	7.231	4.037	0.683E-05	2.726	1.057	7.541	7407.0	-5.165	2.335
240.5	7.026	4.049	0.343E-05	2.735	1.027	7.537	7431.0	-5.485	2.381
263.5	7.115	4.076	0.798E-05	2.753	1.040	7.593	7454.0	-5.098	2.421
287.5	7.406	4.099	0.659E-05	2.769	1.083	7.666	7478.0	-5.181	2.459
311.5	7.495	4.129	0.870E-05	2.790	1.096	7.727	7502.0	-5.060	2.493
335.5	7.484	4.157	0.792E-05	2.809	1.094	7.773	7526.0	-5.102	2.526
359.5	7.624	4.183	0.739E-05	2.826	1.114	7.833	7550.0	-5.132	2.556
455.5	7.935	4.284	0.718E-05	2.895	1.159	8.039	7646.0	-5.143	2.658
479.5	7.926	4.307	0.660E-05	2.911	1.158	8.077	7670.0	-5.180	2.681
503.5	7.920	4.321	0.396E-05	2.921	1.157	8.089	7694.0	-5.403	2.702
527.5	7.915	4.334	0.396E-05	2.930	1.157	8.122	7718.0	-5.402	2.722
576.5	7.912	4.342	0.104E-05	2.935	1.156	8.134	7767.0	-5.985	2.761
601.0	7.909	4.350	0.233E-05	2.941	1.156	8.147	7791.5	-6.633	2.779
623.5	7.856	4.357	0.225E-05	2.946	1.148	8.154	7814.0	-5.648	2.795
647.5	7.955	4.380	0.793E-06	2.948	1.162	8.170	7838.0	-6.101	2.811
671.5	8.003	4.366	0.159E-05	2.952	1.169	8.185	7862.0	-5.800	2.827
699.5	8.100	4.371	0.136E-05	2.956	1.184	8.206	7890.0	-5.867	2.845
744.5	8.147	4.382	0.155E-05	2.963	1.190	8.229	7935.0	-5.810	2.872
767.5	8.143	4.390	0.248E-05	2.968	1.190	8.242	7958.0	-5.605	2.885
793.5	8.141	4.396	0.171E-05	2.973	1.189	8.253	7984.0	-5.768	2.900
815.5	8.191	4.394	-0.581E-06	2.971	1.197	8.256	8006.0	-5.580	2.885
839.5	8.190	4.397	0.783E-06	2.973	1.197	8.260	8030.0	-6.101	2.924
863.5	8.188	4.404	0.185E-05	2.976	1.196	8.271	8054.0	-5.733	2.936
912.5	8.385	4.411	0.104E-05	2.983	1.225	8.307	8103.0	-5.984	2.960
935.5	8.381	4.420	0.275E-05	2.989	1.224	8.322	8126.0	-5.580	2.971
959.5	8.376	4.435	0.423E-05	2.998	1.224	8.346	8150.0	-5.374	2.982

LOAD INCREMENT #13 S.D.= 382 KPA

TIME (HOURS)	VOL DISPL (CC)	AXIAL DISPL (MM)	STRAIN RATE (/HR)	TRUE AXIAL STRAIN %	TRUE VOL. STRAIN %	DEVIATORIC STRAIN %	CUMULATIVE TIME (HRS)	LOGSTRAIN RATE/HOUR	LOGTIME HOURS
0.0	8.372	4.445	0.301E+01	3.006	1.223	8.362	8150.0	0.478	-2.000
0.5	8.368	4.456	0.165E-03	3.014	1.222	8.380	8150.5	-3.808	-0.301
2.0	8.362	4.470	0.634E-04	3.023	1.222	8.403	8152.0	-4.198	0.301
7.5	8.353	4.494	0.300E-04	3.040	1.220	8.442	8157.5	-4.523	0.875
23.5	8.533	4.545	0.218E-04	3.075	1.246	8.548	8173.5	-4.661	1.371
33.0	8.523	4.570	0.180E-04	3.092	1.245	8.590	8183.0	-4.744	1.519
47.5	8.606	4.614	0.210E-04	3.122	1.257	8.674	8197.5	-4.677	1.677
75.0	8.778	4.687	0.182E-04	3.172	1.282	8.817	8225.0	-4.739	1.875
120.5	8.986	4.793	0.161E-04	3.245	1.312	9.021	8270.5	-4.784	2.081
143.5	9.118	4.840	0.141E-04	3.278	1.331	9.116	8293.5	-4.851	2.157
167.5	9.196	4.898	0.154E-04	3.317	1.343	9.222	8317.5	-4.784	2.224
191.5	9.315	4.976	0.225E-04	3.371	1.360	9.369	8341.5	-4.647	2.282
215.5	9.462	4.985	0.239E-05	3.377	1.381	9.400	8365.5	-5.622	2.333
240.5	9.641	5.040	0.153E-04	3.415	1.407	9.515	8390.5	-4.816	2.381