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STRAIN-RATE INFLUENCE ON SHEAR STRENGTH CHARACTERISTICS OF COMPACTED ASELA CLAY

A thesis submitted to the school of graduate studies of Addis Ababa institute of technology in partial fulfillment of the requirement for the degree of Master of Science in Civil Engineering (Geotechnical Engineering stream)

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Declaration

I, the undersigned, declare that this thesis is my original work performed under the supervision of my research advisor Dr. Mesele Haile and has not been presented as a thesis for a degree in any other university. All sources of materials used for this thesis have also been duly acknowledged.

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List of Symbols

A	Area
A_o	Initial area
$\mathring{A}$	Angstrom units
B	Skempton's pore pressure parameter
C	Total Cohesion of soil in kPa
C'	Effective cohesion of soil in kPa
G_s	Specific gravity of soil specimen
H	Height of specimen
ε	Strain
ν	Poisson's ratio
ϕ	Angle of internal friction
ϕ'	Angle of internal friction/effective
σ_c	Confining stress
σ_1, σ_1'	Total and effective major principal stress
σ_3, σ_3'	Total and effective minor principal stress
$\Delta\sigma_a$	Deviator stress
τ	Shear stress

List of Abbreviations

BP	Back pressure
CP	Cell pressure
LL	Liquid Limit
PP	Pore pressure
PI	Plasticity Index
PL	Plastic Limit
CU	Consolidated Undrained test
CD	Consolidated Drained test
UU	Unconsolidated Undrained test
OC	Over consolidated
NC	Normally consolidated
OCR	Over consolidation ratio
OMC	Optimum moisture content
MDD	Maximum dry density
PWP	Pore water pressure

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Abstract

This research work tries to examine the effect of strain rate on shear strength of red clay soil of Asela. It is attempted to identify the effect of strain rate by conducting a series of triaxial compression test and unconfined compression test on remolded soil samples. All the specimens were compacted at optimum moisture content (OMC) with the standard compaction apparatus. Besides basic tests have been done to identify the soil type.

Both unconfined compression tests and triaxial tests were done on samples of 38mm in diameter and height twice the diameter. The type of triaxial test employed was consolidated undrained (CU) with pore pressure measurement and with effective consolidation pressure of 200kPa, 300kPa and 400kPa. After saturation and consolidation stage, the specimen were axially loaded at rate of strain varying from 0.001mm/min to 1mm/min. A total of twelve triaxial consolidated undrained tests and sixty unconfined compression test were run. Data presented includes consolidation data, pore pressure observation, stress-strain relationship and modified Mohr failure envelop diagram. The results of triaxial tests were used to examine the stress strain relationship and shear strength parameters.

The results showed that strain rate affect both stress-strain relationship and strength of soil. As the strain rate increases the strength of the soil also increase but the strain rate has more pronounced effect on cohesion and little effect on angle of internal friction of the soil. The values of cohesion obtained from modified failure envelop for strain rate 0.001mm/min,0.01mm/min,0.1mm/min and 1mm/min were 40.67kPa, 44.38kPa, 64.6kPa and 93.15kPa for total stress and 39.97kPa, 42.85kPa, 51.92kPa and 79.52kPa for effective stress. The value of angle of internal friction obtained from modified failure envelop for strain rate of 0.001mm/min,0.01mm/min,0.1mm/min and 1mm/min are 14.46^0,14.53^0, 14.12^0 and 14.73^0 for total stress and 21.87^0,22.13^0,21.53^0 and 21.02^0 for effective stress.

The unconfined compression test were done on the samples of 38mm in diameter and a height of twice the diameter with seven(7) different strain rates(i.e.0.08,0.4,1,1.52,2,5 and 10mm/min) for remolded clay soils. From the test result undrained shear strength in unconfined compression test is directly related to strain rate effects. A higher strain rate results in higher undrained shear strength for Asela red clay soil. The values of undrained shear strength obtained from unconfined compression test for strain rate of 0.08mm/min, 0.4mm/min, 1mm/min,1.52mm/min, 2mm/min, 5mm/min and 10mm/min are 34.02kPa, 36.95kPa, 37.23kPa, 41.77kPa, 42.70kPa, 47.77kPa and 48.46kPa.

1. INTRODUCTION

1.1 General

Due to complicated structure and composition of soils, the stress and strain relations are not as simple as for the other materials. Soils usually fail due to tensile or compressive stress. The stresses in the soil mass at failure are critical combination of both normal and shear stresses. The shear strength of soil is one of the most important engineering properties of soil in the stability of many foundation engineering related problems such as evaluation of earth pressure, bearing capacity of shallow and deep foundations, slope stability or stability of embankments and earth dams. The shear strength of a soil is indicative of the stability and strength of the soil under various conditions of loading, compaction, and moisture content. However, the shear strength value determined experimentally is not constant, but can vary with the method of testing. When the maximum Shear stress is reached, the soil is regarded to have failed. The failure conditions of a soil may be expressed in terms of limiting shear stress, called shear strength, or as a function of principal stresses.

In the case of saturated clay the behavior of soil can be affected by various factors including pore pressure, the effective stress, loading path and the history of loading. The response of clay soil is highly dependent on the rate of straining and loading for both effective stress path and stress strain behavior. All viscous and plastic materials offer resistance to shearing strain varying with the speed at which shearing strain are applied. A considerable research work has been done to determine the shear strength parameters of clay in the country. The purpose of this research is to show how strain rate affect the stress strain relationship and shear strength characteristics of clay in Asela area.

The strength of cohesive soils is affected by the rate at which the external load is applied. Bearing capacity of foundation is also affected by the rate of loading since it is a function of shear strength. For instance, the loading rate while driving pile significantly affects the strength of soil. However, the current understanding of the results of varying strain rate on soil behavior is often ignored in design, field studies, laboratory testing and soil mechanics frame works.

The shearing resistance of soil is constituted of the following main components (Kamari 2009):

- ✓ The structural resistance to displacement of the soil because of the interlocking of the particle
- ✓ The frictional resistance to translocation between the individual soil particles at their contact points

- ✓ Cohesion or adhesion between the surfaces of the soil particles

Three types of laboratory shear strength test available in laboratory of school of civil and environmental engineering where strain rate play significant role in its determination. These are direct shear test, triaxial compression test and unconfined compression test. The main task of this thesis is to conduct unconfined compression test and consolidated-undrained triaxial test with different strain rates on the remolded fine grained soil samples. When civil engineering structures rest on the ground, they induce stress on the underlying soil and the stress will be distributed in the soil mass. Depending on the engineering property, the response of the soil to the applied stress is different.

1.2 Objective of the Study

The main objective of the study is to investigate the effect of strain rate on shear strength parameters of Asela red clay soil obtained from consolidated undrained triaxial test and unconfined compression test under different shearing rates.

1.3 Methodology

In the current thesis research work as a method to perform the intended research work, review of the literatures has been done for revising the accepted theories and practices in the topic areas at hand. As part of methodology to perform the research, sample collection and series of laboratory tests to reveal different natures and behavior have been carried out.

Based on the theories and laboratory tests performed, the results obtained have been analyzed and discussed thoroughly. Finally, the findings and results of the research have been reported. The different activities that were carried out in this research are classified into three phases. Pre-field work, field work and post field work. Each of the three steps comprise different activities. The main activities in the pre-field work were literature review and field preparation. During the field work stage, visual identification of soils around the study area and sampling were made.

The main objective of the research is to show the effect of strain rate on shear strength of clay by conducting laboratory strength test considering different strain rates. Therefore, due to simplicity and sampling convenience, remolded sample from specific location have been considered in this study.

During post-field work, laboratory tests were conducted on collected samples and some of the geotechnical properties were determined. Both unconfined compression test and consolidated undrained tri-axial tests were done on samples of 38mm diameter and a height of twice of diameter. The type of test employed was unconfined compression test and consolidated Undrained (CU) with pore pressure measurement and with effective consolidation pressure of 200kPa, 300kPa and 400kPa. After saturation and consolidation stage the specimen were axially loaded at rates of strain 0.001mm/min to 1.0 mm/min.

The strain rates were selected in such a way that slow strain is determined using BS standard and then a range of strain are chosen referring a slow strain rate. Accordingly, the reference strain rate was calculated to be 0.1mm/min. two strain rate (0.01mm/min and 0.001mm/min) which are taken below the reference strain rate and are considered as slow strain rates. In similar manner higher strain rates (1mm/min and 10mm/min) are taken above the reference strain rate. A total of sixteen triaxial compression test and forty unconfined compression test were run.

1.4 Limitation of the study

It was initially intended to collect samples from five areas of Asela where red clay is found and conduct forty five unconfined compression test using five different strain rates. Due to the addition of the consolidated undrained test and electric power problem at the national level for the failure on triaxial machine to perform and the time for the lab work was limited due to insufficient number of laboratory equipment to accommodate large number of students cause to reduce the number of samples to be conducted and shortage of financial support restricted the domain of the study areas in to only four areas of Asela with the one test pit for each areas. It would have been worth to open additional test pits and collect samples from additional areas where red clay soil is found.

1.5 Organization of study

The thesis has a total of five chapters. Chapter one deals with the general behavior of soils as the back ground. It also includes the objective of the thesis work, scope and limitations of the thesis, as well as organization of the thesis. Chapter two is totally devoted to literature review, Chapter four summarizes all laboratory tests conducted and their results. The results and findings are discussed in chapter five. Chapter six contains conclusion and indicates points for further researches. Appendix-A comprises all laboratory index test. The detail information and result for laboratory unconfined compression test are attached in appendix B. Appendix C shows all the consolidated undrained triaxial test result and graphs. Reference section, which lists down the books and academic materials that have been reviewed, is dedicated for citation to acknowledge the materials and authors.

2 Literature Review

2.1 Introduction

In geotechnical engineering a wide range of strain rates are encountered either through field and laboratory testing of soils, through to the lifespan of geotechnical structures. The potential for soils to display strain rate effects may have implications for the choice of field testing techniques, as well as how these techniques are factored to account for strain rate effects. To account for strain rate effects in geotechnical engineering requires testing of site specific strain rate dependence. Relating strain rate effects to fundamental soil properties would provide industry with the means to evaluate rate potential of soils without the necessity of empirical site specific testing.

To get some understanding on the factors which influence strain rate effects, and the behavior of soils as they are tested at different strain rates, a review of factors involved in the strain rate dependence of soils has been conducted. Existing relationships between strain rate effects and shear strength parameters of soils, as well as the current understanding of strain rate effects on soil behavior at small strains and high strain rate has also been discussed. Previous investigations into the rate dependence of soil using the triaxial apparatus are also reviewed.

2.2 Strain rate dependent soil behavior in Geotechnical Engineering

With increasing strain rate the response of soil changes, and the subsequent effect on the strength of a soil may be very significant. Figure 2-1 presents results from Lehane et al. (2009) where the resistance to penetration of normally consolidated Kaolin was measured at strain rates varying over 5 orders of magnitude using a T-bar penetrometer. At lower strain rates; an increase in strain rate corresponds to decreasing resistance. With increasing strain rate, the maximum strength of the soil continues to decrease until a minimum resistance is measured, where the response of the soil changes, and will begin to display increasing resistance with a further increase of strain rate. The behavior of normally consolidated Kaolin shown in Figure 2-1 is consistent with results of other penetrometer studies in fine grained soils conducted in both field testing and laboratory studies (Bemben and Meyers, 1974, Roy et al., 1982,Randolph and Hope, 2004, Kim et al., 2008). The variation of resistance with increasing strain rate in Figure 2-1 reflects true strain rate dependent behavior of fine grained soils.

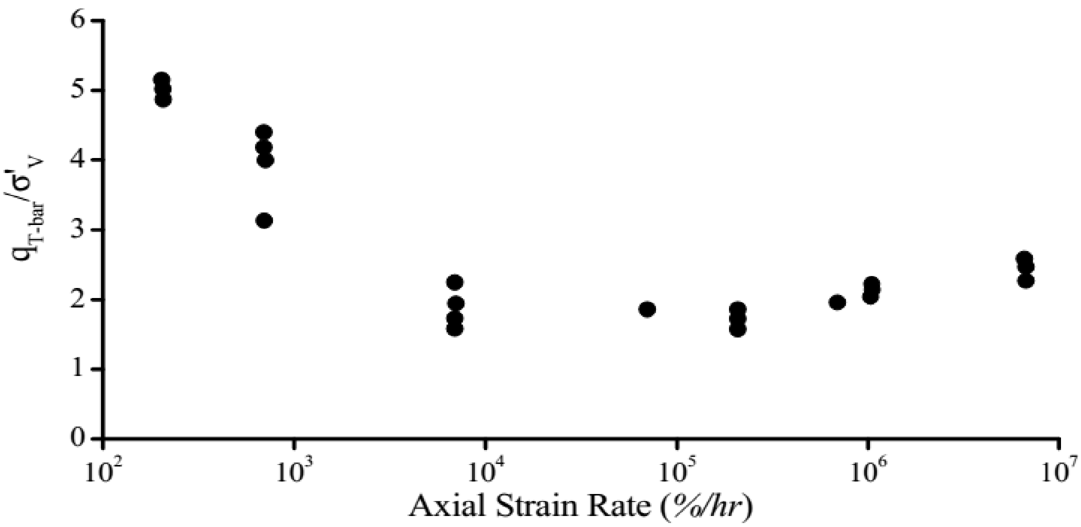


Fig 2.1 variation of normalized T-bar penetrometer resistance in normally consolidated kaolin at increased strain rate (Lehane et al., 2009)

According to Lunne et al. (1997) at very slow strain rates, where the behaviour of soil is fully drained, the resistance is independent of strain rate. With increasing strain rate the effective stress reduces causing a reduction in resistance (Figure 2-1). This continues until a strain rate is reached whereby viscous effects come to influence the soil's resistance, offsetting the reduction in effective stress (and strength) and the resistance reaches a minimum. With further increase of strain rate the viscous effects come to dominate and the soil's resistance will increase. At lower strain rates in Figure 2-1 this behaviour is consistent with the partially drained behaviour of Weald clay at different strain rates tested in a triaxial cell shown by Carter (1982). Carter (1982) conducted a numerical and experimental study on the effect of strain rate on strength in drained triaxial tests. Carter (1982) found that with increased strain rate the strength of the soil reduces due to the development of excess pore pressures and decreasing influence (time) of consolidation. The effect of strain rate in this domain was thus termed the partially drained strain rate effect. At higher strain rates Carter (1982) found the response of the soil became undrained and the soil displayed its true minimum strength.

An idealized version of these effects are summarized in Figure 2-2 from Quinn and Brown (2011), which highlights the four different domains of soil behaviour in relation to strain rate. The key aspects of the aforementioned studies is the apparent transition from partially drained to undrained behaviour, whereby the soil response changes from decreasing to increasing strength/resistance with an increase in strain rate. This point is labelled the transition in Figure 2-2. The potential viscous limit in the fourth domain in Figure 2-2 reflects the shear thinning behaviour (for undrained strain rate effects) of soils at increased strain rates (Guven, 1992).

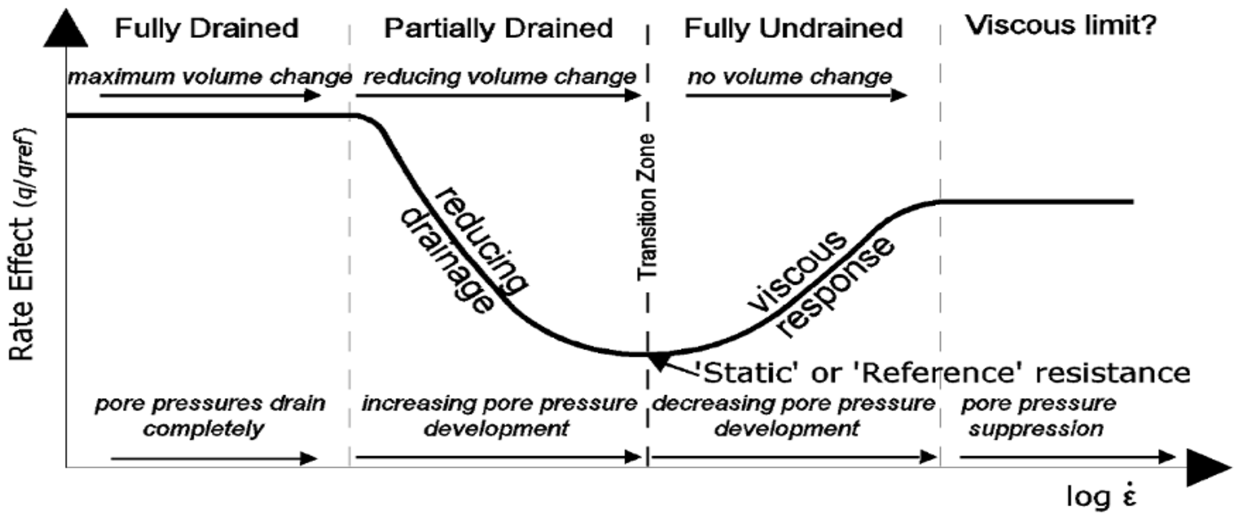


Fig 2.2 Idealized 'Backbone' curve, identifying the four different domains of strain rate dependent soil behaviour (Quinn and Brown, 2011)

2.3 Factors affecting partially drained strain rate effect on strength

The partially drained strain rate effect, corresponding to the second domain in Figure 2-2 discussed previously, has been related to decreasing effective stress due to increasing excess pore pressure development (Carter, 1982, Randolph and Hope,2004, Kim et al., 2006, Salgado et al., 2013). The increase in excess pore pressures is due to the decrease in consolidation with increased strain rate. Finnie and Randolph (1994) found for model foundations tested at various penetration rates in calcareous sediments, the partially drained strain rate effect could be accounted for by normalizing the velocity of penetration using the coefficient of consolidation;

$$V = \frac{Vd}{Cv} \quad \text{-----------------------------2.1}$$

Where v is the velocity of penetration, d is a characteristic length (often assumed as the drainage path length) and Cv is the coefficient of consolidation. This method of normalizing the penetration rate has been successfully used in several studies to account for the effects of partial consolidation at increased rate (Randolph and Hope, 2004, Kim et al., 2006, Lehane et al., 2009). An example of the effect of the normalised velocity is shown in Figure 2-3 which presents the effect of strain rate on the strength of Kaolin from Lehane et al. (2009).The results from Lehane et al. (2009) are from T-bar penetration tests in a centrifuge, where the tests were conducted at various strain rates and depths.

Figure 2-3 shows that normalization of the strain rate using Equation 2-1 reduces the variation of the results considerably for the partially drained strain rate effects. It was suggested by Lehane et al. (2009) that use of Equation 2-1 is not appropriate for strain rate effects in the undrained domain, where consolidation does not occur

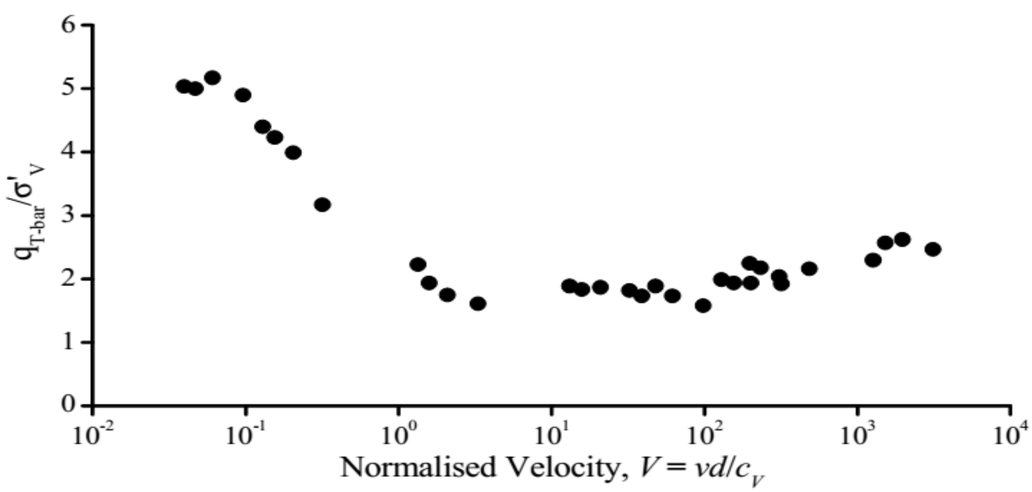


Fig 2.3 Effect of normalized velocity on normalised T-bar penetrometer resistance measurements in kaolin (Lehane et al., 2009)

2.4 Factors affecting undrained strain rate effect on strength

Although the factors affecting the partially drained rate effects have been related to the coefficient of consolidation, the factors which affect the undrained strain rate effect are not well understood. Because an increase in shear strength with increasing shear rates is characteristic of viscous materials it is often considered that undrained strain rate effects are due to the viscosity of soils (Whitman, 1957, Lunne et al.,1997). Tatsuoka et al. (2008) attributes the response of soil to stepwise changes in strain rate to the type of inter particle contacts, whilst others postulate it may be influenced by the viscosity of absorbed water (Richardson, 1963, Briaud and Garland,1985). Observations of soil behaviour in stepwise changes to strain rate and the viscosity of water in soils are reviewed here. Observations regarding the effect of strain rate on effective stress are discussed, as well as how over consolidation effects the undrained strain rate effect on strength.

2.4.1 Effect of stepwise change in strain rate

The behaviour of both fine grained and coarse grained soils subjected to stepwise change in strain rate has been investigated in several studies (Richardson and Whitman, 1963, graham et al., 1983, Oka et al., 2003, Sorensen et al., 2007, Tatsuoka et al., 2008).

An example of the effects of stepwise change in strain rate of undrained monotonic triaxial testing in reconstituted London clay is shown in Figure 2-4 from Sorensen et al. (2007).

The stress-strain curves from stepwise changes in strain rate agree with those from constant strain rate tests at their respective strain rates (Richardson and Whitman,1963).

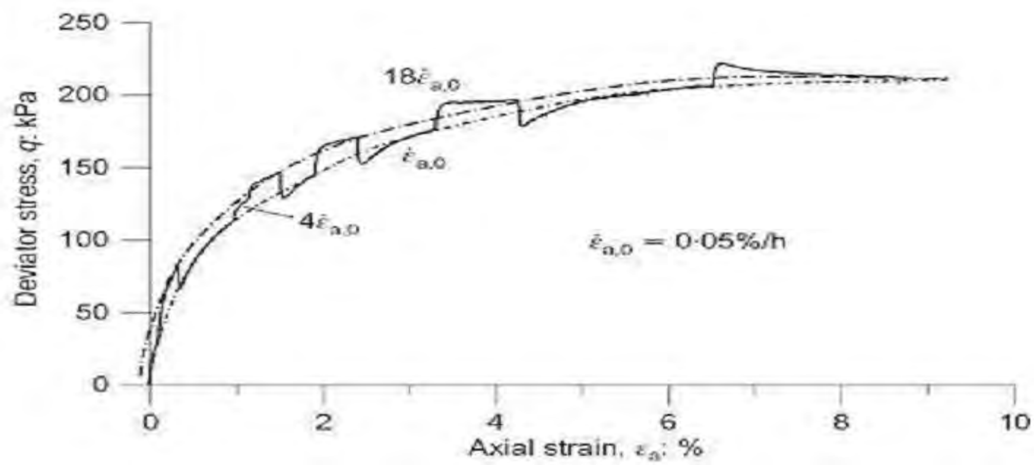


Fig 2.4. The stress strain behavior of London clay subjected to stepwise changes in strain rate (Sorensen et al., 2007)

Sorensen et al. (2007) found the behavior of the normally consolidated, reconstituted London clay subjected to step-wise changes in strain rate depended on strain level, displaying isotach behavior (following unique stress-strain paths for each strain rate) at lower strains, and increasingly Temporary Effect of Strain Rate and strain Acceleration type behavior (a temporary increase in stress-strain path followed by a return to the original path) at higher strain.

2.4.2 The effect of strain rate on effective stress

As described previously the partially drained strain rate effect corresponds to increased excess pore pressure and reducing effective stress with increased strain rate (Figure 2-2). Regarding undrained strain rate effects on strength, reports in literature are often contrary to each other in terms of how increased strain rate affects excess pore pressures. Some studies report excess pore pressures are independent of strain rate (Akai et al., 1975, Soga and Mitchell, 1996), whilst other studies report the magnitude of excess pore pressures reduce with increasing strain rate (Sheahan et al.,1996). It appears that no studies on strain rate effects have observed increasing excess pore pressures with strain rate where the response of the soil is undrained.

Both Soga and Mitchell (1996), who tested natural Pancone clay at strain rates from 0.3 to 3%/hr., and Lefebvre and LeBoeuf (1987) who tested several natural clays from Eastern Canada at strain rates from 0.05 to 132%/hr., found that excess pore pressures were independent of strain rate. These findings are in agreement with Graham et al.(1982) who also tested a variety of natural soils at strain rates from 0.002 to 10%/hr. However these observations that excess pore pressures are independent of strain rate are possibly linked to the presence of an intact natural structure; tests on the same soils without their natural structure showed a dependence of excess pore pressures on strain rate (Lefebvre and LeBoeuf, 1987).

Akai et al. (1975), who conducted monotonic triaxial compression tests in remolded Fukakusa clay at strain rates up to 3000%/hr., assumed there was no obvious effect of strain rate on excess pore pressures. For the majority of tests shown, no distinct relationship emerges between the magnitudes of excess pore pressures and increasing strain rate (0.0109-14.81%/min). Akai et al. (1975) assumed the variability of excess pore pressures indicate independence of strain rate. However, the fastest strain rate test (49.4%/min) displays significantly lower excess pore pressures. Notably Akai measured pore pressures at the base of the sample. Measurements of pore pressure taken at the base of the sample may be subject to end effects, which may be responsible for the variability in the magnitude of excess pore pressures at lower strain rates (0.0109 - 14.81%/min)

Decreasing excess pore pressures with increasing strain rate are widely reported in the literature (Richardson and Whitman, 1963, Lefebvre and LeBoeuf, 1987, Sheahan et al., 1996, Balderas-Mecca, 2004). Lefebvre and LeBoeuf (1987) who tested natural fine grained soils from Eastern Canada found that when these soils were destructured, the magnitude of excess pore pressures decreased when tested at higher strain rate. As mentioned above, when the same soils were tested with their natural structure the excess pore pressures did not display a dependence on strain rate. A decrease in excess pore pressure with increased strain rate (at maximum strength) is often described as pore pressure suppression, and is cited as the primary mechanism responsible for strain rate effects in reconstituted soils in both normally consolidated (Lefebvre and LeBoeuf, 1987) and over consolidated state (Sheahan et al., 1996).

For normally and lightly over consolidated soils Sheahan et al. (1996) also measured an increase in the effective stress friction angle at maximum deviatoric stress. Other studies including Bjerrum et al. (1958), Alberro and Santoyo (1973), Hight (1983), O'Reilly (1989) and Crawford (1959) all report slight increases in peak angle of friction with increasing strain rate.

2.5 Triaxial studies on strain rate effects

This section reviews and discusses some previous investigations into undrained strain rate effects with triaxial systems. Some key aspects of each study are highlighted in the historical review to give a perspective of previous investigations of strain rate effects.

Casagrande and Shannon (1948) conducted one of the first triaxial based studies into the relationship between soil strength and the time to failure. A specialized triaxial apparatus was required to perform high speed monotonic loading. To do this three separate loading systems were used, a pendulum, falling beam and hydraulic apparatus. Times to failure ranged over 6 orders of magnitude from 10,000 seconds to 0.01 seconds. Four natural soils were studied, three of which were fine grained and one coarse grained. It was found that the strength of all cohesive soils tested displayed a dependence on the time to failure; however the non-cohesive soil displayed minor rate effects. Some of the fine grained soils were air dried to lower their water content and thus provide a range of strengths for each soil. The samples with a lower static strength displayed higher rate effects.

Richardson and Whitman (1963) compared triaxial undrained compression tests on normally consolidated Mississippi River valley clay at strain rates between 0.12%/hr. And 60%/hr. Of particular note, an objective of this study was to address water migration and non-uniformity (as well as strength increase) during high strain rate triaxial compression testing. With increasing strain rate an increase in strength was accompanied by a decrease in excess pore pressures. A comparison of the pore pressures measured at the base and mid height showed that with increasing strain rate the base transducer consistently measured higher pore pressures, highlighting the effect of non-uniformity of stress distribution with increasing strain rate. However no redistribution of water was observed in the post test samples. To address possible effects of moisture distribution during shear at higher strain rate, a step-changing technique was used where the strain rate was suddenly increased from 0.12%/hr. to 60%/hr. The results from step changed tests agreed well with those from steady strain rate tests (in terms of measured strength and excess pore pressure). This is today referred to as isotach behaviour. Thus the isotach behaviour indicated that migration of moisture was not responsible for the increase in strength seen at higher strain rate.

Akai et al. (1975) conducted normally consolidated undrained triaxial tests on remolded Fukakusa clay using a loading system capable of delivering stable and constant rates of strain at rates from 0.12%/hr. to 3000%/hr. The strength was found to be proportional to the strain rate however the excess pore pressures were found to be independent of strain rate, although notably pore pressure was measured at the base of the sample. It is possible the excess pore pressures measured by Akai et al. (1975) were likely were artificially large due to the effects of end restraint. The resulting effective stress path increasingly diverged from the static stress path with strain rate, tending towards the total stress path. Akai et al. (1975) also conducted tests on other time dependent soil mechanical phenomena including stress relaxation tests and creep tests. Empirical formulations for these phenomena and constant rate of strain tests were shown to be equivalent.

Lefebvre and LeBoeuf (1987) conducted undrained triaxial tests with monotonic and cyclic loading on three natural clays in both structured and destructured states. The monotonic tests were strain controlled at rates ranging from 0.05%/hr. to 132%/hr. and the stress controlled cyclic tests were conducted at 1 – 2 Hz, equivalent to strain rates of up to 6000%/hr. The magnitude of the strain rate effect for the clays in structured and destructured state was found to be almost identical, however the mechanisms attributed to the strain rate effect on strength for each state was different. For destructured soils a decrease in excess pore pressures was measured with increasing strain rate and thus the shear resistance is attributed to the change in effective stress. For structured clays the excess pore pressures was independent of strain rate and the shear resistance was attributed to the bonding within the clay skeleton. It is noted that no mention of the location of the excess pore pressure transducer was made by Lefebvre and LeBoeuf (1987). Therefore these findings on excess pore pressures may be suspect if they were recorded at the base transducer. However the general trends of their results tend to agree with those from studies incorporating mid height excess pore pressure measurement.

Sheahan et al. (1996) compared the effect of strain rate on reconstituted Boston blue clay anisotropically consolidated to OCR from 1 to 8. Lubricated ends and a mid-height excess pore pressure transducer were incorporated to address the issue of non-uniform distribution of strains. However a relatively narrow range of strain rates from 0.05%/hr. to 50%/hr. were studied, which is considerably lower then used by Akai et al. (1975) or Lefebvre and LeBoeuf (1987). With increasing OCR the effect of strain rate was seen to generally reduce. Sheahan et al. (1996) found that at OCR 1 and 2 the strain rate effect on strength was caused by both suppression of shear induced pore pressures and an increase in effective stress (friction angle), however at OCR 4 and 8 the effect was entirely due to a decrease in shear induced pore pressures.

Balderas-Mecca (2004) conducted tests at strain rate tests from approximately 2%/hr. to 350,000%/hr., far in excess of previous studies, using a pneumatically loaded triaxial system with an artificial soil which was designed to model the mechanical behaviour of a natural fine grained soil. The strain rate effect increased linearly with the logarithm of strain rate. However the rapid introduction of the displacement piston into the triaxial cell caused a significant increase in cell pressure during shear. The deviatoric stress and excess pore pressures were thus corrected for differences cause due to the rapid increase in cell pressure. Despite this the excess pore pressures were found to decrease significantly with increased strain rate.

In summary these studies each found significant difficulties in measurement of excess pore pressures during shear. As discussed previously, with increasing strain rate excess pore pressures are generally seen to reduce. The effects of non-uniformity were addressed by Richardson and Whitman (1963) and Sheahan et al. (1996) using step changing techniques and lubricated ends respectively. Nonetheless the shear strength increased with an increase in strain rate and a decrease in excess pore pressures was still observed. Unfortunately most of the studies described previously utilized a narrow range of strain rates, typically quite low in comparison to those in other geotechnical applications. The study from Balderas-Mecca (2004) could unfortunately suffer from cell pressure changes during shear, masking true effective stress behaviour as well as possibly influencing the shear strength.

This summary of previous triaxial studies highlights the necessity for a high strain rate investigation of strain rate effects on strength, where difficulties noted in previous investigation are addressed. Further to the works of Casagrande and Shannon (1948) and Lefebvre and LeBoeuf (1987), there is also a necessity for a triaxial investigation incorporating a variety of soils, with the purpose of defining the dependence of strain rate effects on soil properties.

3 Laboratory Test Results

3.1 General

Soil samples were collected from known areas, Kebele 09('chigign mefelfeya'), Kebele 08('Eidgat besira' School), kebele 11, and Bale bar where red clay soils are found. One test pit was opened at each site and disturbed and undisturbed samples were taken. The moisture content was determined immediately after sampling and transported it to laboratory by warping with plastic bag to avoid moisture loss. Undisturbed samples were kept under tube sampler sealed with wax and wrapped with plastic bag and moist clothes. Disturbed samples were air dried to constant moisture and sieved with different sieve sizes after pulverizing depending on the requirement of specific test procedures.

Different laboratory tests were conducted on the soil sample according to the need. Among these are Atterberg limits, particle size analysis, specific gravity, free swell, compaction, unconfined compression tests and triaxial compression test.

Disturbed soil samples were air dried and oven dried at 105 degree centigrade according to the need for the type of specific requirement of the test procedure. Soil remolding for the specified testes were done at OMC with standard compacting effort.

3.2 Moisture Content

The moisture content of the soil which is defined as the ratio between mass of water to mass of soil grains was determine immediately after the sample was taken from the site. The samples were kept in plastic bag to prevent moisture loss during transportation from site to laboratory.

The method employed for determining the moisture content was oven drying method. The measured amount of wet soil was put in an oven of 105 degree centigrade and kept for 24 hours and examined for weight loss. The result of moisture content determination is as follows.

Table 3.1 moisture content at a depth of 3m during sample collection

No:	Pit Description	Moisture content, %
1	Kebele 09 pit 1	28.3
2	Kebele 08 pit 2	27.8
3	Kebele 11 pit 3	29.9
4	Bale bar pit 4	29.8

3.3 Specific Gravity Determination

Specific gravity which is the measure of heaviness of the soil particles were determined by the method of small pycnometer method using a soil sample passing 2mm sieve and oven dried at 105 degree centigrade. The specific gravities of four test pits are determine and stated below. (Appendix A)

Table 3.2 Specific gravity of soils at depth of 3.0m, 3m, 2.8m and 2.6m respectively shown in table 3.2

No:	Pit Description	Specific Gravity
1	Kebele 09 pit 1	2.76
2	Kebele 08 pit 2	2.78
3	Kebele 11 pit 3	2.73
4	Bale bar pit 4	2.69

3.4 Atterberg Limits

Soil samples passing 425 micro meter sieve were used for Atterberg limits determination. Casagrande's apparatus was used for the determination of liquid limits. For the determination of plastic limit, a soil sample was rolled in to 3mm thread until it begins to crumble. The results of Atterberg limits and plastic limits are calculated to be 61% and 28% respectively for kebele 09. (The detail is given in appendix A)

3.5 Free Swell Test

Swelling tendency was also determined from the samples passing 425 micrometer sieve and oven dried. The 10ml of soil sample was put in water for 24 hours and swelling was examined as percentage of volume change to the original volume. The results obtained are as follows.

Table 3.3 Free swell

No:	Pit Description	Specific Gravity
1	Kebele 09 pit 1	48
2	Kebele 08 pit 2	45
3	Kebele 11 pit 3	38
4	Bale bar pit 4	50

3.6 Hydrometer Test

An oven dried sample passing 75 micrometer sieve was used for particle size analysis. Sodium hexametaphospate was used as dispersing agent and mechanical stirrer was also used. An average laboratory temperature was 20 degree centigrade. H151 ASTM standard hydrometer was employed. The test was conducted According to ASTM D422 and the results obtained are plotted blow.

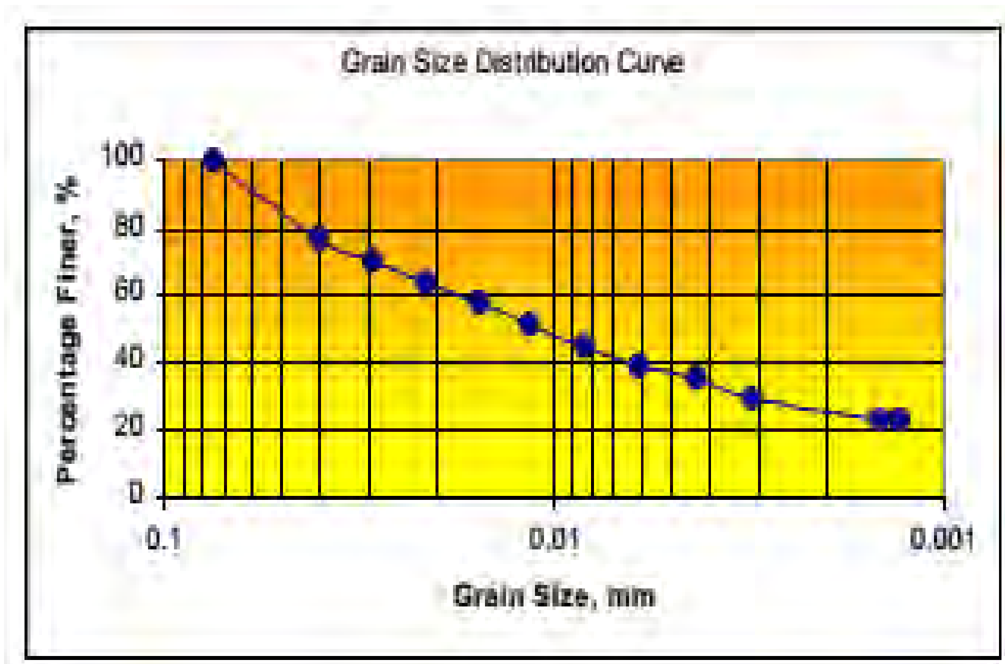


Fig 3.1 particle size distribution for Kebele 09 ("chigign mefelfeya") pit 1

3.7 Standard Compaction Test

Standard proctor compaction test was used to obtain the moisture-dry density relationship of the specific soil samples. It is done in a 4 inches diameter mold with a 2 Kg rammer falling from 305 mm height. The soil was compacted with different moisture content in three layers each suffering 25 blows. After obtaining the density and moisture of the each compacted soil sample, the following relationships for dry density and moisture content are obtained.

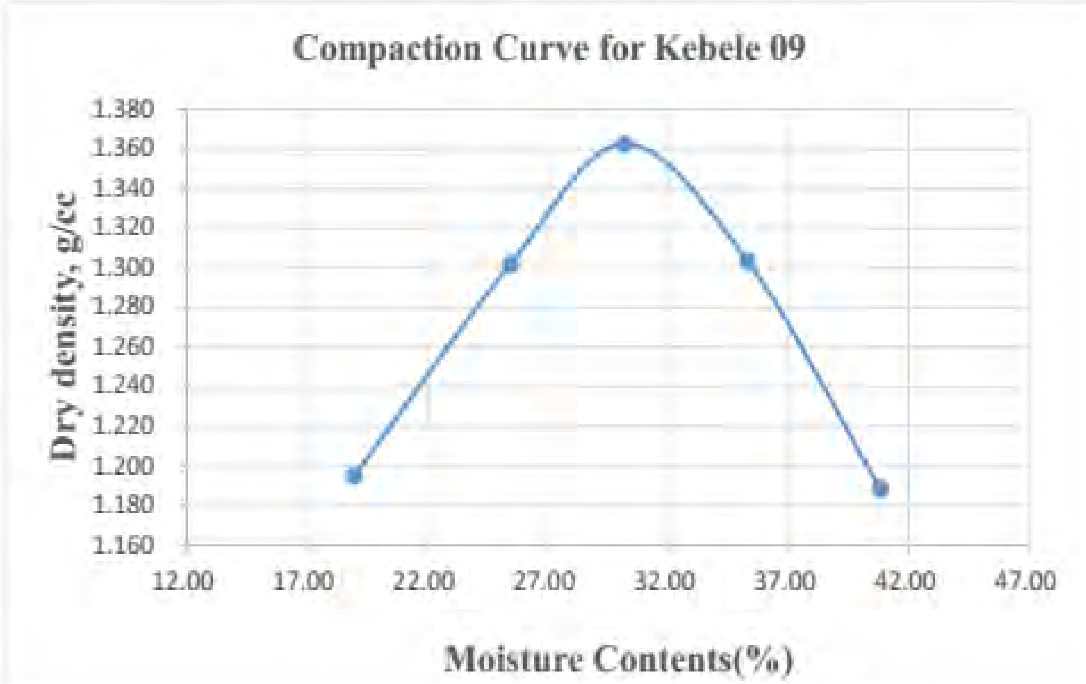


Fig 3.2 standard compaction curve for Kebele 09(“chigign Mefelfeya”) pit 1

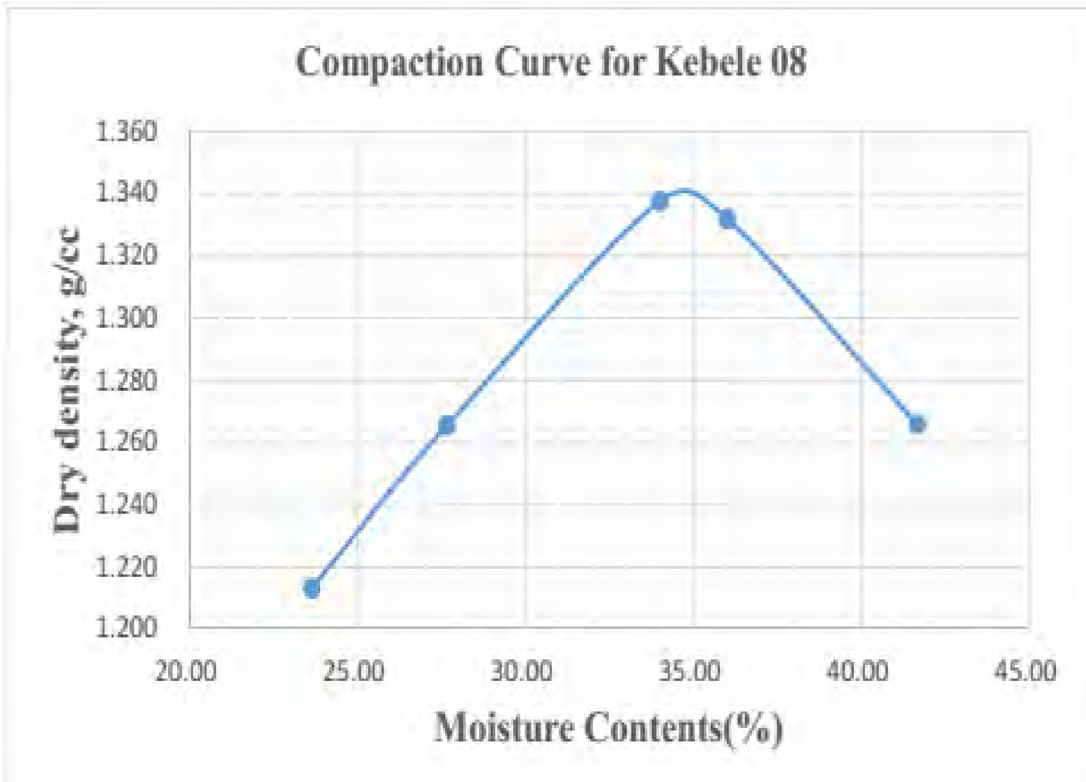


Fig 3.3 standard compaction curve for Kebele 08 (“Edgat Besira School”) pit 2

From the compaction curve, the optimum moisture content and maximum dry density is determined to be as shown below in table 3.4

Table 3.4 optimum moisture content (OMC) and Maximum Dry Density (MDD)

No:	Pit Description	OMC, %	MDD, g/cc	Wet density, g/cc
1	Kebele 09 pit 1	30	1.36	1.78
2	Kebele 08 pit 2	34	1.34	1.81
3	Kebele 11 pit 3	32.5	1.36	1.72
4	Bale bar pit 4	27.5	1.51	1.92

3.8 Unconfined Compression Test

Unconfined Compression Test also known as Uniaxial Compression Tests, is special case of a triaxial test, where confining pressure is zero. An Undisturbed or remolded sample of cylindrical shape, about 38mm in diameter and 76mm in height is subjected to uni-axial compression until the soil fails. Since the sample is laterally unconfined, only cohesive soils can be tested. The sample is tested quickly and there is no drainage. Therefore, it is special case of the UU test in which σ_3=0. However, rather than in a triaxial cell, the test is performed in mechanical apparatus specially manufactured for this purpose. Unconfined Compression test does not require the sophisticated triaxial setup and is simpler and quicker test to perform as compared to triaxial test. In this test, a cylinder of soil without lateral support is tested to failure in simple compression, at a constant rate of strain. The compressive load per unit area required to fail the specimen as called unconfined compressive strength of the soil.

In the unconfined compression test, we assume that no pore water is lost from the sample during set-up or during the shearing process. A saturated sample will thus remain saturated during the test with no change in the sample volume, water content, or void ratio. More significantly, the sample is held together by an effective confining stress that results from negative pore water pressures (generated by menisci forming between particles on the sample surface). Pore pressures are not measured in an unconfined compression test; consequently, the effective stress is unknown. Hence, the undrained shear strength measured in an unconfined test is expressed in terms of the total stress

Table 3.5 General Relationship of Consistency and Unconfined Compression Strength of Clays

Consistency	Qu kN/m^2
Very soft	0-25
Soft	25-50
Medium	50-100
Stiff	100 -200
Very stiff	200-400
Hard	>400

Because the undrained shear strength is high as the soil is fully saturated and fully independent of confining pressure as undrained.

One of the test result obtained are shown below for quick reference and detail test data and result are attached in appendix B

3.8a) Unconfined compression test result for strain rate of 0.08 mm/min

Table 3.6 unconfined compression test result

Length(mm)	76		strain Rate (mm/min)		0.08
Diameter (mm)	38		sample number		#1
Area(m2)	0.001134115		sample type		Remolded
project area	kebele 08		Depth		3.00m
Def.mm	Strain (%)	R_3=1-strain	Load in N	corrected area=Ao/R_3	stress (kPa)=P/Ac
0	0	1	0	0.001134115	0.000
0.1	0.13157895	0.9987	15	0.001135609	10.567
0.5	0.65789474	0.9934	41	0.001141626	17.519
0.7	0.92105263	0.9908	46	0.001144658	27.082
0.9	1.18421053	0.9882	53	0.001147706	38.337

1.1	1.44736842	0.9855	54	0.001150771	39.973
1.2	1.57894737	0.9842	56	0.001152309	44.200
1.4	1.84210526	0.9816	61	0.001155399	45.810
1.6	2.10526316	0.9789	63	0.001158505	46.549
2	2.63157895	0.9737	68	0.001164767	49.863
2.15	2.82894737	0.9717	70	0.001167133	51.443
2.22	2.92105263	0.9708	71	0.00116824	53.869
2.5	3.28947368	0.9671	73	0.00117269	56.281
2.56	3.36842105	0.9663	75	0.001173648	56.128
2.8	3.68421053	0.9632	78	0.001177496	57.671
3.33	4.38157895	0.9562	80	0.001186084	60.896
3.36	4.42105263	0.9558	81	0.001186574	62.416
3.4	4.47368421	0.9553	83	0.001187228	67.291
3.5	4.60526316	0.9539	81	0.001188865	68.038
3.6	4.73684211	0.9526	81	0.001190507	67.013
3.7	4.86842105	0.9513	80	0.001192154	66.920
3.9	5.13157895	0.9487	80	0.001195461	65.992
4.1	5.39473684	0.9461	80	0.001198786	61.729
4.2	5.52631579	0.9447	79	0.001200456	56.645
4.5	5.92105263	0.9408	76	0.001205493	53.090
5.1	6.71052632	0.9329	70	0.001215694	50.177
5.5	7.23684211	0.9276	67	0.001222592	49.076
6.6	8.68421053	0.9132	65	0.00124197	43.838
8.25	10.8552632	0.8914	65	0.001272218	40.874
9.5	12.5	0.875	64	0.001296131	36.262
10.5	13.8157895	0.8618	64	0.00131592	34.197
12.5	16.4473684	0.8355	63	0.001357366	30.942

Unconfined compressive strength, q_u:	68.04
Undrained shear strength, s_u:	34.02

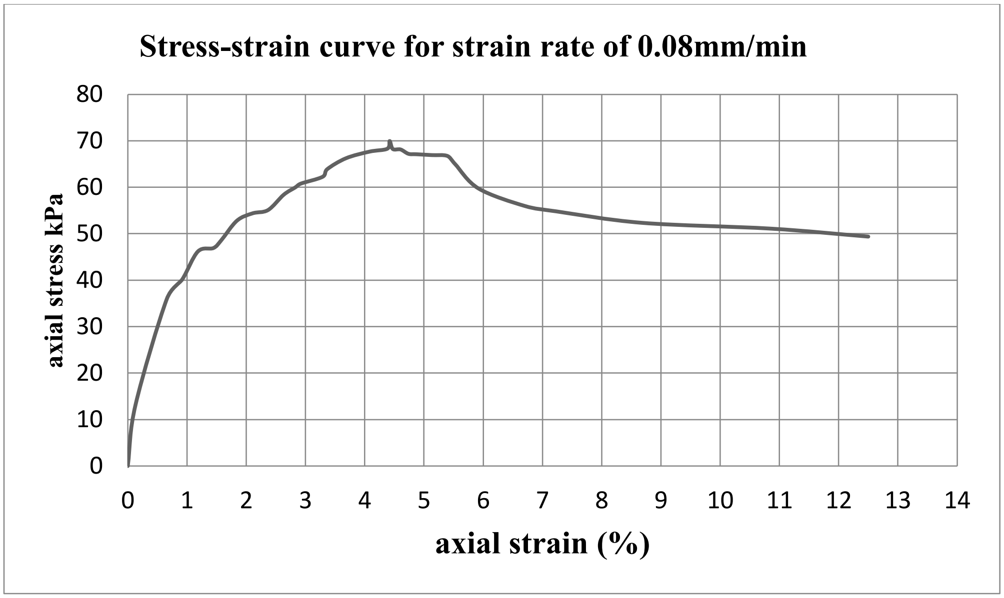


Fig 3.4 unconfined compressive strength of Asela keb. 09 for strain rate of 0.08mm/min (68.04Kpa)

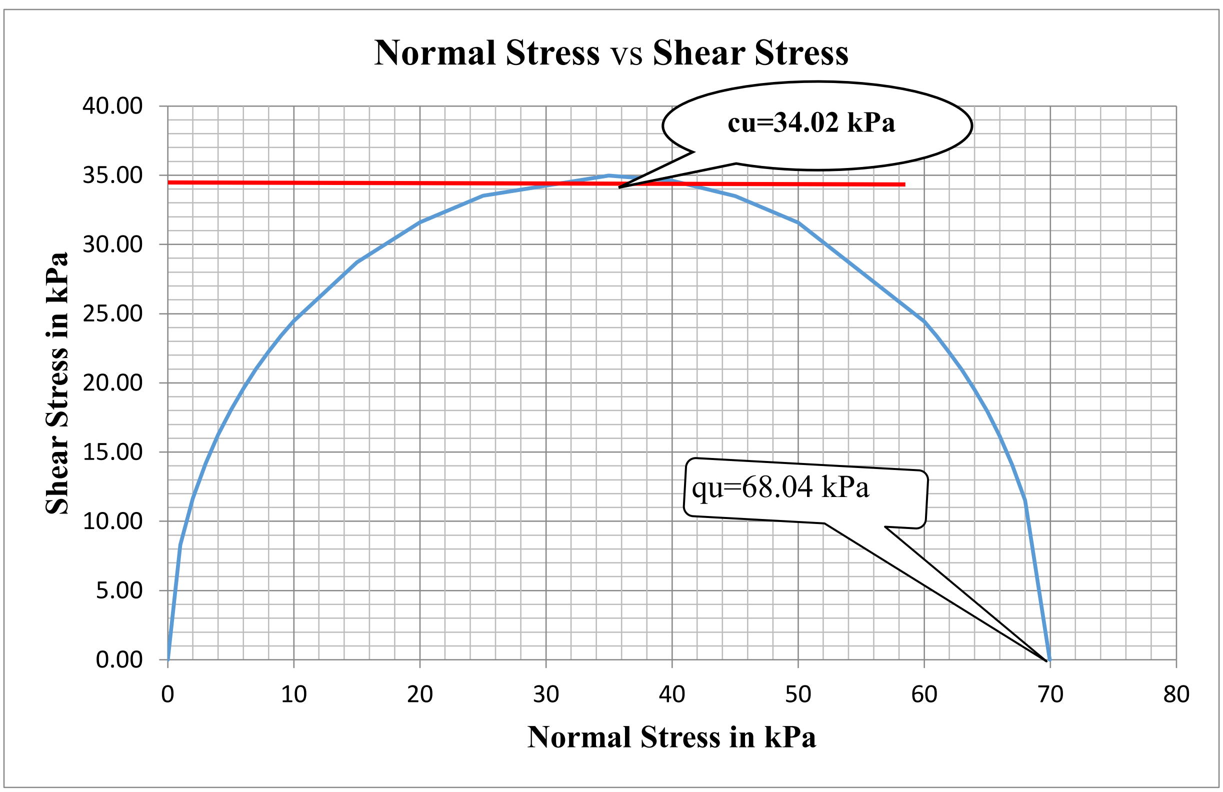


Fig 3.5 Mohr's Circle for the unconfined compression Test

3.9 Triaxial Compression Test

Triaxial compression test was conducted to study the stress-strain and strength behavior of the soil, on undisturbed and remolded, specimens of diameter 38mm and height is twice the diameter.

CU test with pore pressure measurement was employed for the advantage of time and obtaining both total stress and effective stress parameters. Under this test three main stages called saturation, consolidation and compression/shearing were performed.

Saturation was done according to BS 1377 part 8 clause 5.3, saturation by increment of cell pressure and back pressure. Pore pressure parameter B was checked at each cell pressure increment as controlling mechanism for saturation and for the B value of 0.95 and more; it was considered as the soil was saturated. 50kPa of cell pressure increment and 10kPa of back pressure difference from cell pressure were used for saturation. It was seen that the soil was saturated for the back pressure of 200kPa to 400kPa.

Consolidation stage was performed for the selected effective consolidation pressures of 200kPa, 300kPa and 400kPa to bring the soil at three different effective stresses. Consolidation stages were continued until 95% or more excess pore pressure dissipates and volume change was almost ceased. It is worth noting here that indicating information like time for 100% consolidation obtained from consolidation stage was used in compression stages for calculating and adjusting the machine speed as rate of axial displacement. Shearing or compression was done as final stage by calculating axial displacement rate and continued until about 20% of axial strain and one of the failure criterion stated in BS 1377, part 8 clause 1.2.8 (maximum deviator stress, maximum effective principal stress ratio and shearing under constant pore pressure) was clearly observed.

As stated in BS 1377, the modified failure envelop method was employed to determine the effective shear strength parameters. This method was employed to use the advantage of convenience and to eliminate the difficulty of obtaining tangent line for three points on three circles of Mohr’s failure diagram (Arora, K.r., 1997).

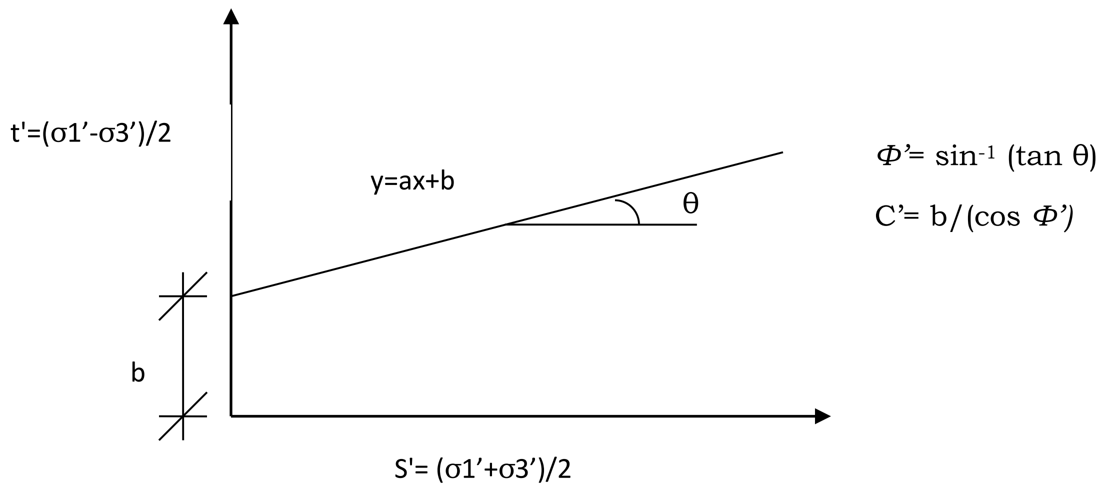


Fig 3.6 Modified Failure envelope

Mohr-Coulomb Failure criterion

$$\frac{\sigma 1-\sigma 3}{2}=\left(\frac{\sigma 1+\sigma 3}{2}\right)*sin\emptyset+Ccos\emptyset$$

$$\mathrm{Y}=ax+\mathrm{b} \qquad a=\tan\theta=sin\emptyset'$$

$$\mathrm{b}=C\cos\phi$$

4 Discussion of the Test Results

4.1 Introduction

In this chapter, the result obtained for the variation in strength of Asela clay with increasing rates of strain observed from unconfined compression tests are first discussed and a consolidated undrained triaxial test have been analyzed to study the effect of strain rate on the stress-strain behavior and shear strength parameters of Asela red clay soil.

4.2 Unconfined Compression Tests

The unconfined compression test is by far the most popular method of soil shear testing because it is one of the fastest and cheapest method of measuring shear strength. The method is used primarily for saturated cohesive soil recovered from thin walled sampling tube. The test were done on the samples of 38mm in diameter and height of twice the diameter with seven (7) different strain rate**.**

The test results of unconfined compression tests are presented in the form of stress-strain relationship in Fig.4.1. The strain at failure and corresponding unconfined compressive strength at different rate is tabulated as table 4.1.

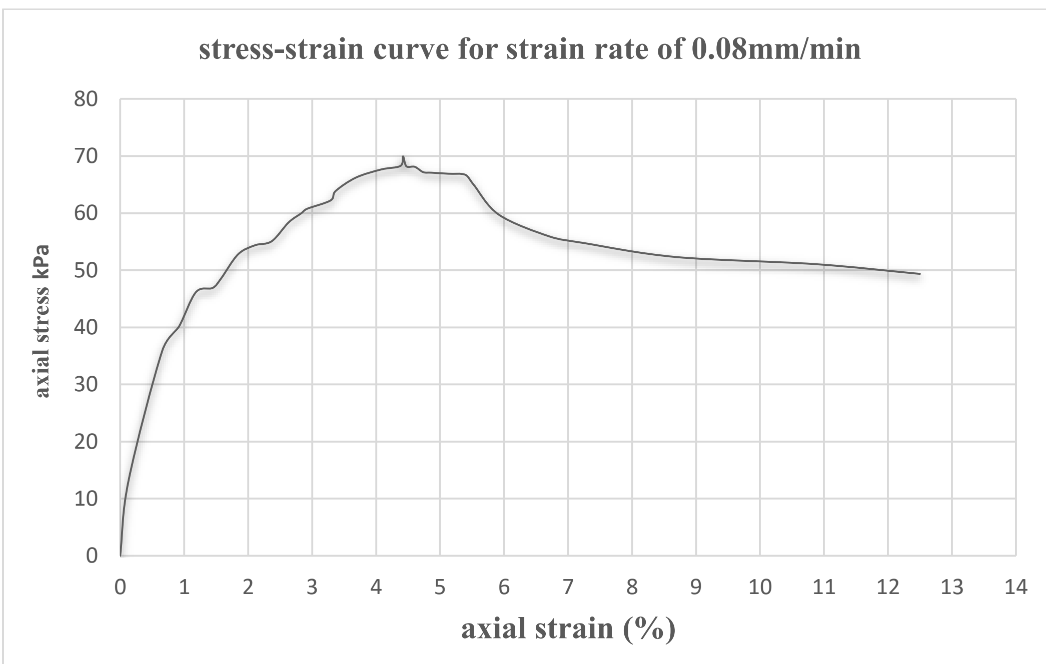


Fig.4.1 stress-strain curve for strain rate of 0.08mm/min

Table 4.1 the average unconfined compression and shear strength of Asela red clay soil under different strain rate

Strain rate in mm/min	Unconfined compressive strength,kPa	Undrained shear strength, kPa
0.08	68.04	34.02
0.40	72.90	36.95
1.00	74.45	37.225
1.52	83.535	41.767
2.00	85.390	42.695
5.00	95.53	47.77
10.00	96.92	48.46

The result of Unconfined Compression test on the Asela red clay soil with different strain rates at OMC and MDD are shown in table 4.1. Table 4.1 shows unconfined compression strength and undrained shear strength increases considerably with increase in strain rate.

4.3 Triaxial Compression Tests

4.3.1 Selection of shear rate

The triaxial compression test in this thesis work were performed under undrained condition where the soil specimen was a consolidated undrained test. In consolidated undrained test, the displacement rate at which the specimen should be sheared is very important and it depends greatly upon the drainage characteristic that is permeability of the soil. Because the ability of the

soil to permeate is closely related to coefficient of consolidation, the consolidation test can provide the data for estimating suitable time to failure. The objective of consolidation stage is to bring the specimen to the state of effective stress required for carrying out the compression test.

Data obtained from consolidation stage are used for estimating and adjusting a suitable rate of strain to be applied during compression, for determining when consolidation is complete, and for computing the dimensions of specimen at the start of the compression stage.

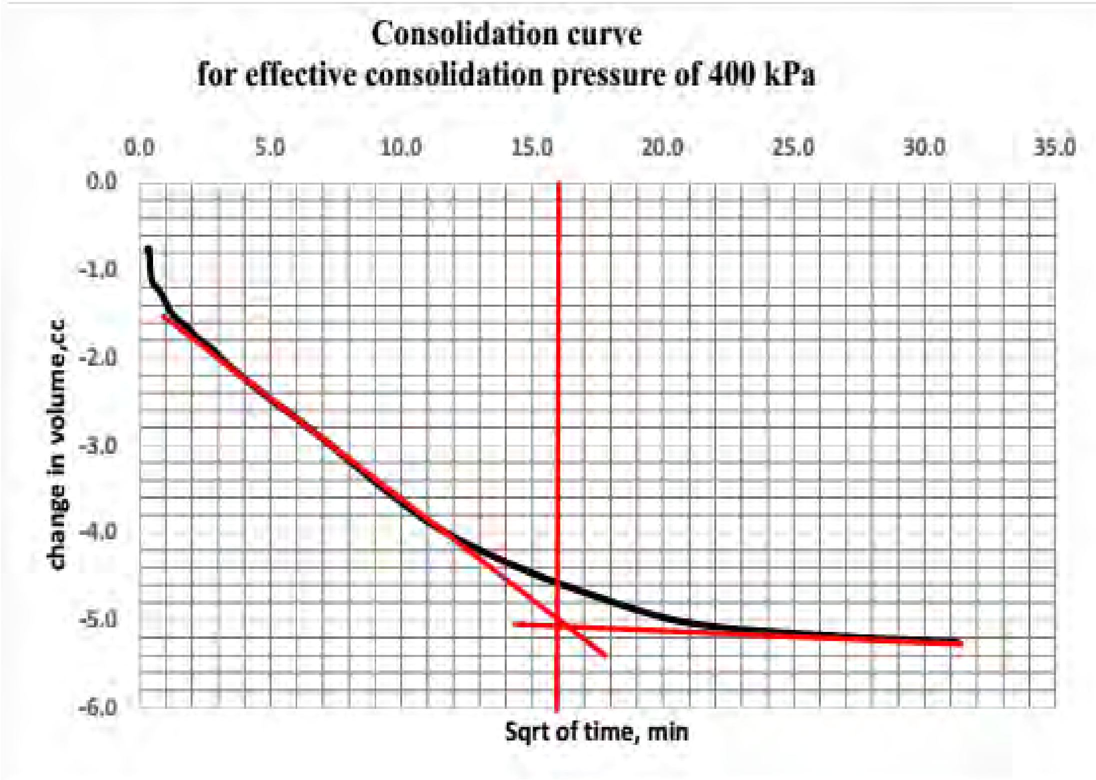


Fig. 4.2 Idealized triaxial consolidation curve

Fig.4.2 illustrate a plot of measured volume change against square-root time obtained from consolidation stage of triaxial test. Draw the straight line which best fits the early portion of the plot of volume change against square-root time (this portion normally lies within about the first 50% of volume change readings). Draw a horizontal line through the final point on the plot (see Fig 4.2). At the point where these lines intersect read off the value square-root time, denoted by √100 and calculate the time intercept of this point, t_{100} (in min). The time for 100% consolidation was calculated from the graph for all tests and found to be similar (t100=220.24 min) for three confining pressure in all tests. The minimum time Thus, the strain rates calculated from BS 1377, part 8 clause 6.3.8 have also similar results (dr= 0.102 mm/min). The rate obtained is slower and taken as the reference strain rate. The rate of 0.001mm/min,0.01mm/min had been chosen as slow strain rate for consolidated undrained test on saturated specimen. In similar manner 1mm/min and 10mm/min are taken above the reference strain rate.

4.3.2 Stress-strain

Fig.4.3 presents the deviatoric stress-strain curves with the same strain rate and different confining pressures. From these graphs it is observed that an increase in confining pressures shifts the stress-strain curve upward. Change in strain rate does not affect the relationship that an increase in effective consolidation pressure shifts the stress-strain curve upward. The deviatoric stress measured at different strain rate is presented for 200 kPa effective consolidation pressures (Fig.
4.3). Figures 4.4 show the stress-strain curves for the same confining pressures under different strain rates. These plots show how strain rates affect the stress-strain behavior of the soil. The graph shows that the strain rate has a clear impact on the stress-strain relationship, i.e. as strain rate increase the deviatoric stress induced due to axial loading also increase for the same confining pressure.

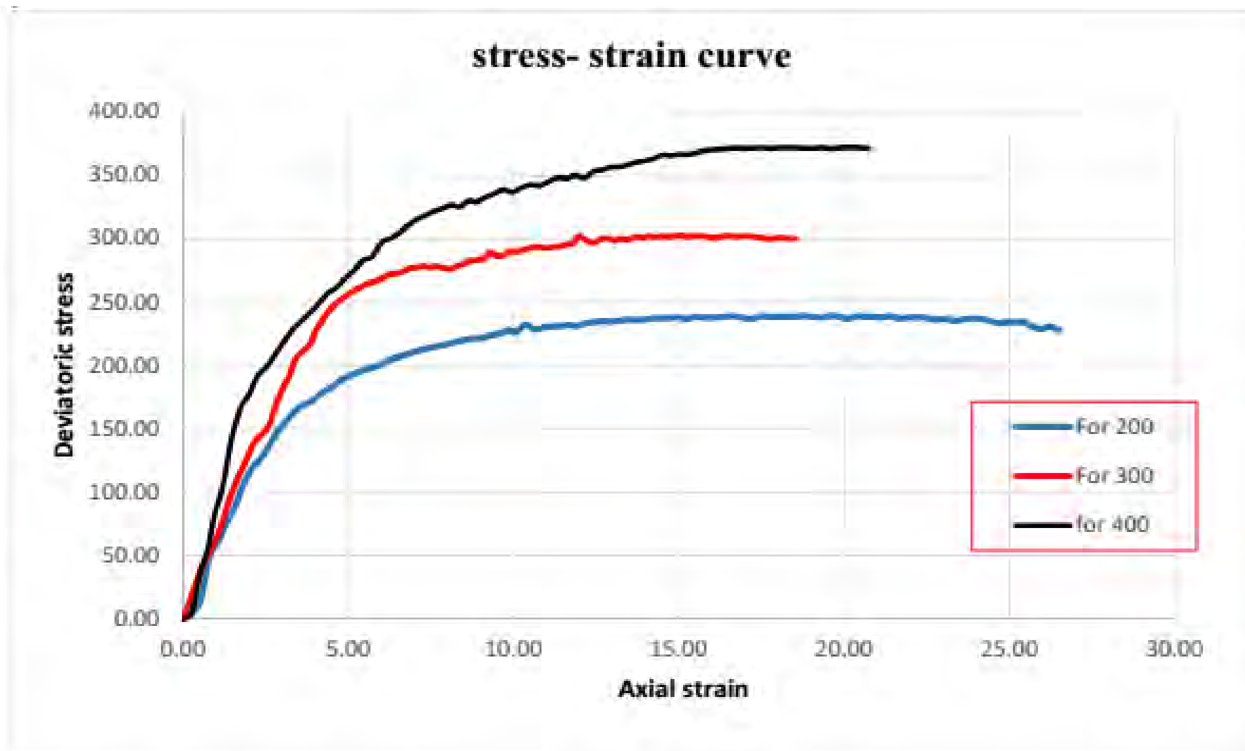


Fig.4.3 tress-Strain curve for strain rate of 0.001mm/min under different Effective consolidation pressure

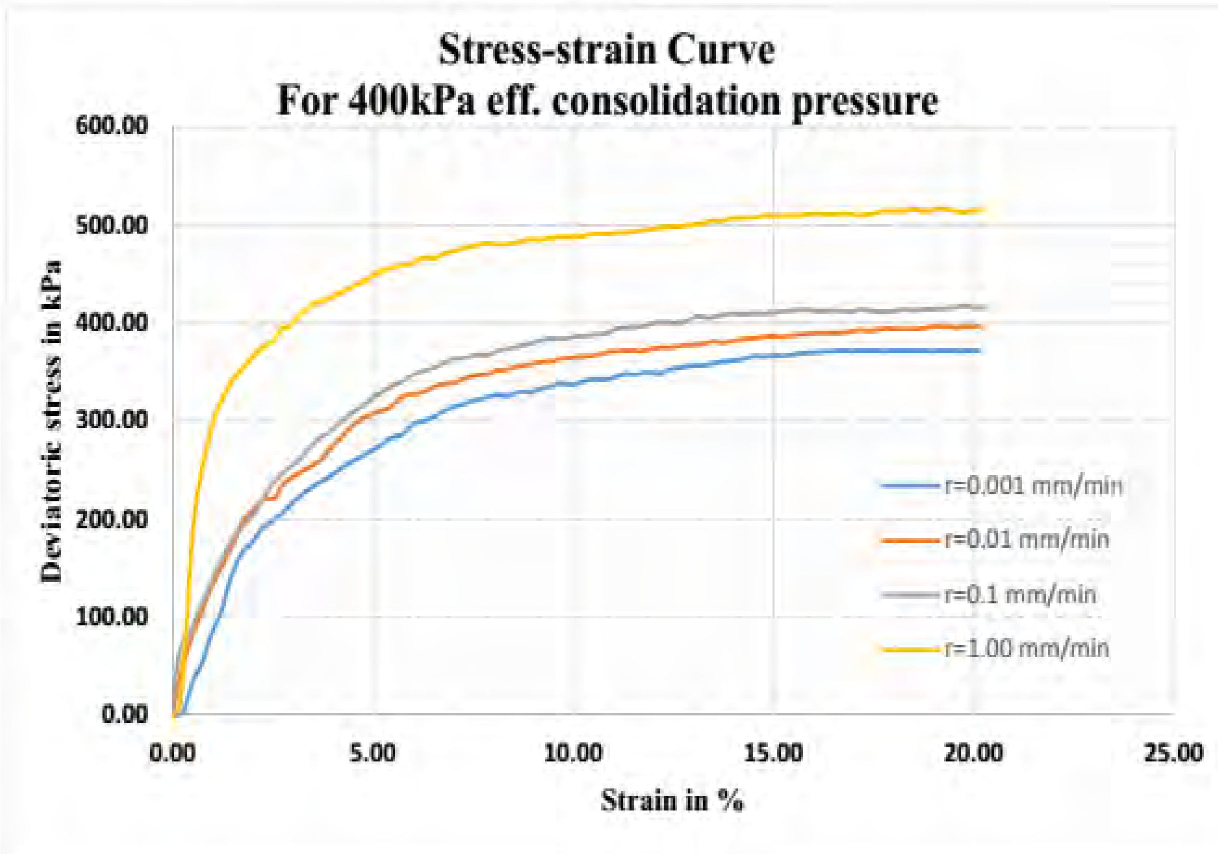


Fig.4.4. Deviatoric Stress-strain curves for 400kPa effective consolidation pressure under different strain rate.

Table 4.2 summary of deviatoric stress result at failure from stress-strain curve

Strain rate in mm/min	Confining Pressure in kPa		
	200	300	400
	Deviatoric stress in kPa at failure		
0.001	239.01	302.87	372.26
0.01	250.92	325.01	398.65
0.10	303.48	351.06	416.96
1.0	415.02	441.75	516.76

The strength increases with increasing rates of strain because of reduced time available for stress deformation. The test duration and rate of strain (rate of loading) significantly affect the strength of compacted clay. Most clay minerals encountered in Asela clay were thin plates, hence the surface area to mass ratio of most clay particles was sufficiently high that forces particle surfaces become of significance in influencing the behaviour of particles. Generally, when saturated clay are subjected to deviatoric stress, a large number of interparticle contacts are disrupted, with some particles being oriented on plane of incipient failure. In testing the present Asela clay, at slower strain rate of strain, it was observed that strength decreased and the behaviour was attributed to breakdown of the structure of the soil. Also, test results show that the increased in strength at faster rate of strain was due to the increase in strength with time of the specimen. In this study the strain rate increases as strength increase.

4.3.3 Pore Water Pressure

Using the data obtained in Table C3 to C9 in appendix c, the excess pore water pressure was plotted against the rate of strain (see Figure 4.6). A decrease in excess pore water pressure occurred for all the cell pressure (200, 300 and 400 kN/m^2) with an increasing rate of strain.

Figure 4.6 shows the induced pore water pressure versus axial strain. Here there is a shift in pore water pressure versus axial strain upward as the confining pressure increase.

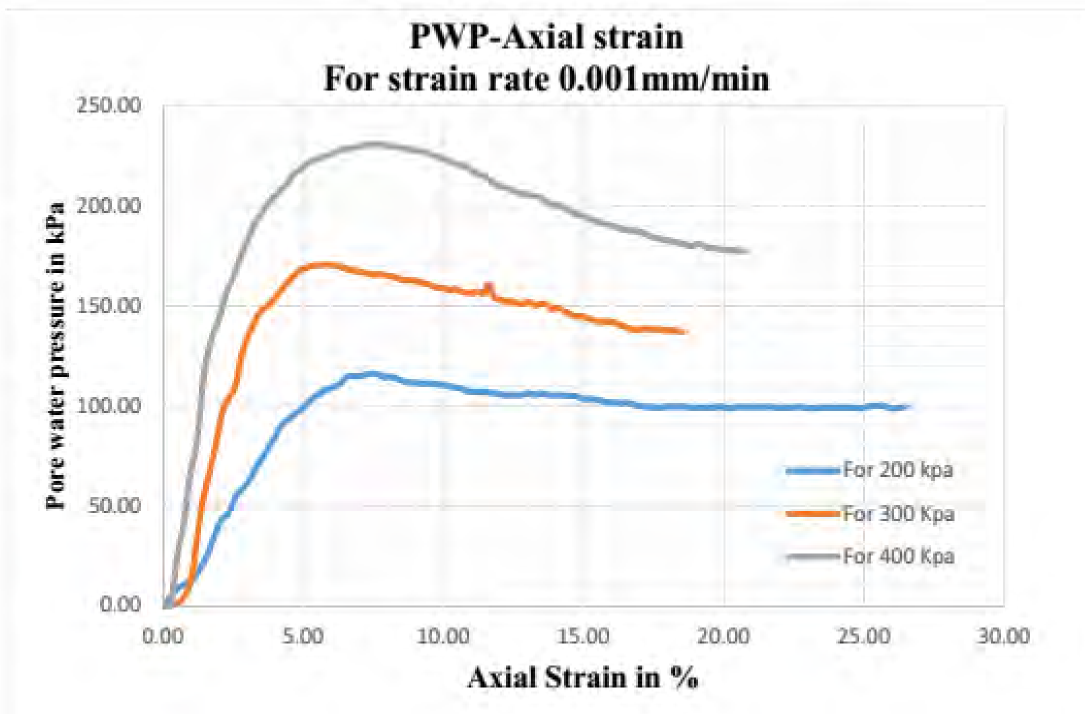


Fig. 4.5 PWP-Strain curve for strain rate of 0.001mm/min under different Effective consolidation pressure

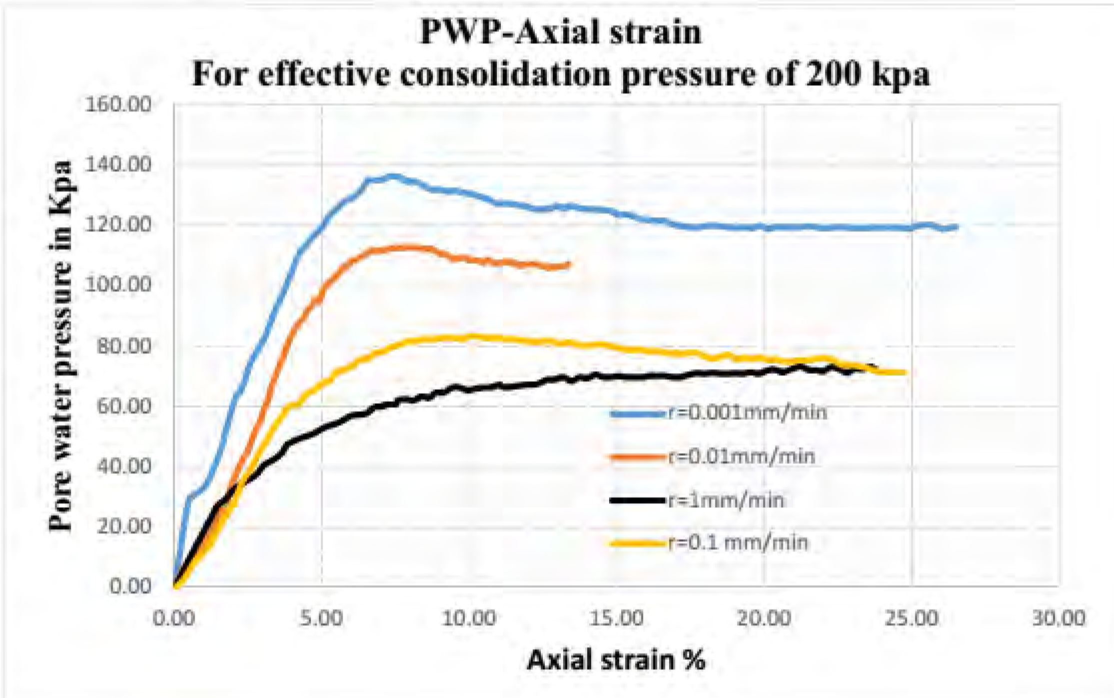


Fig. 4.6. PWP-strain curves for 200kPa Effective consolidation pressure under different strain rate.

Plot of induced pore water pressure versus axial strain with the same confining pressure at different strain rate are shown by Fig.4.6. From the graph, it is observed that the pore water pressure induced by axial loading decrease as strain rate increase. This may be due to the difference in equalization of pore water pressure within the soil.

The increase in pore water pressure is not significant for slow strain rates. Besides, the inability to develop negative pore water pressure (as indicated by the difference in the shape of pore water pressure versus axial strain curve). For higher strain rate, due to the lower period of time to produce suction (cavitation) with in the soil during the compression of triaxial test. The time to complete the triaxial test for compression stage using strain rate from BS (0.1mm/min) is between 3Hr to 4Hr. while the time required for strain rate below BS standard (0.01mm/min and 0.001mm/min) is 12Hr to 16Hr. and 3days to 5days respectively. Around 30min is enough to complete a triaxial compression test for higher strain rate i.e. 1mm/min.

Table 4.3 summary of pore water pressure under different confining pressure and different strain rates

Strain rate in mm/min	Confining Pressure in kPa		
	200	300	400
	Pore Water pressure in kPa (at failure)		
0.001	98.99	144.23	178.19
0.01	96.06	140.00	174.07
0.10	75.94	136.68	168.98
1.0	69.69	106.70	147.67

Generally, strength decrease with increasing pore water pressure as a result of in time to failure. This result is attributed to the change in the soil structure caused by the principal stress difference (deviator stress) and reaches equilibrium within undrained test. The writer believes that the pore water pressure is influenced by confining cell pressure due to structure weakening caused by shear stress. The decrease in pore pressure as a result of faster rates of strain might be due to the shorter time for the development of pore water pressure in the voids and incomplete destruction of bonds in the soil. In this study it also observed that pore water pressure continued to increase with time to failure, and the strength was consistent with the concept that pore pressure development is uniquely related and independent of rate of strain.

Crawford (1959) maintained that stress and pore water pressure at failure depends on the rate of strain. Crawford (1963) found on his studies that pore pressure measurements at the base and within undisturbed specimens of sensitive clay during consolidation and shear indicate that increasing rate of strain during a test reduces the pore pressure slightly and causes increased shearing resistance. Richardson and Whitman (1963) found that for saturated remolded fat clay, pore pressures decreased with increasing rate of strain, but or strains of less than 1.0 %/min excess pore water pressure was independent of strain-rate. Wu (1971) summarizing the findings of several researchers concluded that " when sheared in the undrained condition (such as in a consolidated undrained triaxial test), the pore pressure decreases with increasing strain-rate"

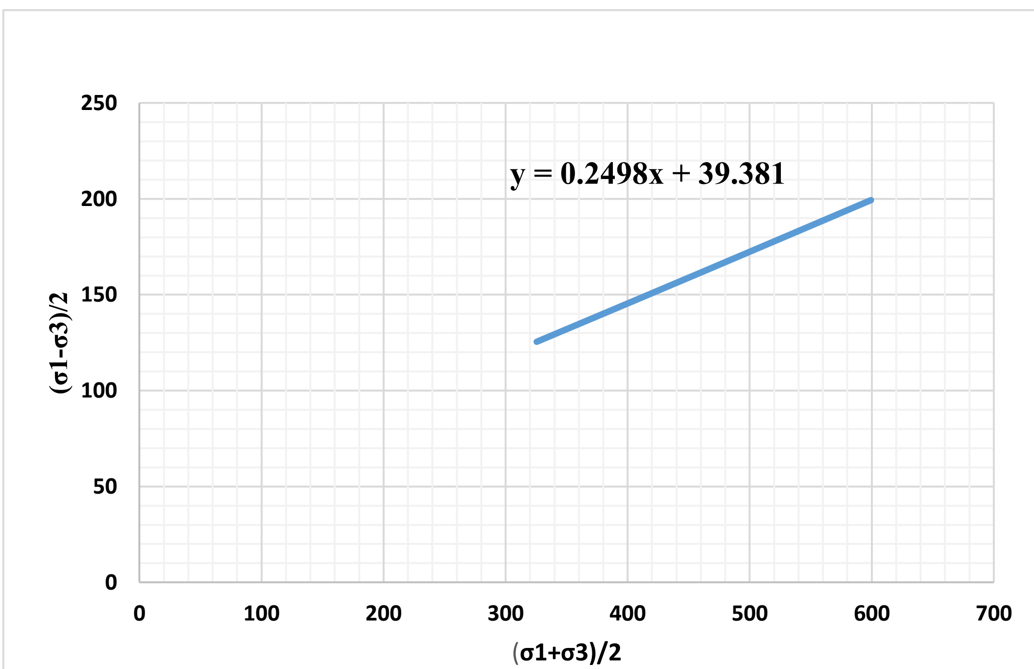
4.3.4 Strength Parameters (cohesion and angle of internal friction)

In this study, the normal and shearing stress on the probable plane of failure was derived using Modified Mohr-coulomb diagram (see Figures 4.7) using rates of strain of 0.001, 0.01, 0.1 and 1mm/min, the corresponding effective cohesion (C') and effective angle of internal friction were obtained. The modified failure envelop is more convenient than Mohr-circle because it is difficult to draw the required tangent touching all circles on Mohr-circles. A Modified failure envelop is plot between p and q values at failure. Where, $q=\frac{\sigma 1-\sigma 3}{2}, q=\left(\frac{\sigma 1+\sigma 3}{2}\right)$

The rates of strain adopted are believed to be relatively slow to allow equalization of pore water pressure at failure. A summary of important results is contained in Table 4.4 and 4.5 for total and effective stress.

Fig. 4.7 Modified failure envelope for strain rate of 0.001mm/min

Effective consolidation pressure(kPa)	Pore water pressure at failure	Deviatoric stress at failure, kPa	(σ1+σ3)/2	Total angle of internal friction	Total cohesion, kPa
200	**98.99**	**239.11**	**319.56**	**14.46°**	**40.67**
300	**144.23**	**302.87**	**451.44**		
400	**178.19**	**372.26**	**586.13**		



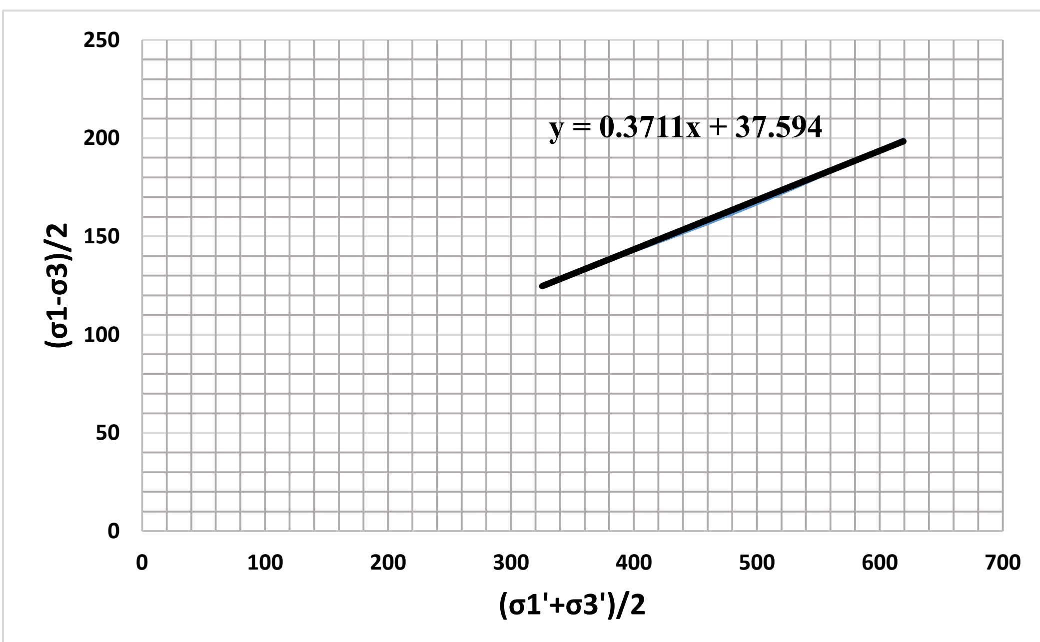
$\Phi = 14.46^0$		C = 40.67 kPa

Table 4.4 the total angle of internal friction and cohesion for different strain rate is summarized

Strain rate in mm/min	Total angle of internal friction (^{0})	Total cohesion kPa
0.001	14.46	40.67
0.01	14.53	44.38
0.10	14.12	64.60
1.00	14.73	93.15

Fig. 4.8 the effective angle of internal friction and cohesion for strain rate of 0.001mm/min

Effective consolidation pressure(kPa)	Pore water pressure at failure	Deviatoric stress at failure, kPa	(σ1'+σ3')/2	Effective angle of internal friction	Effective cohesion, kPa
200	98.89	239.11	220.67	21.87°	39.97
300	144.23	302.87	307.20		
400	178.19	372.26	400.10		



Φ' =21.78°		**C' = 39.97 kPa**

Table 4.5 the effective angle of internal friction and effective cohesion for different strain rate

Strain rate in mm/min	Effective angle of internal friction (^{0})	Effective cohesion kPa
0.001	21.87	39.97
0.01	22.13	42.85
0.10	21.53	51.92
1.00	21.02	79.52

Included in tables are values obtained for total or effective cohesion and Total (effective) angle of internal friction at different rates of strain. It can be seen from table that with an increasing rates of strain, total or effective angle of internal friction also increase. However, it has been observed that effective cohesion undergoes a reduction after attaining a peak value at a very small strain and showed a slight decrease at faster rates of strain. As the rates of strain is further increased, effective cohesion demonstrates an increase value. The reduction in effective cohesion after reaching a maximum at a very small strain has been shown to have no significant effect on the behavior of the strength for Asela clay in this study. Shear strength increases as rates of strain are increased.

The result of this study is close agreement with the findings obtained by various researchers on strain-rate effect on strength parameters, c’ and φ’. Casagrande and Wilson (1951) and Taylor (1957) maintained that cohesion increases with increasing strain rate when tested under undrained and unconfined compression. Gisbon (1953) who worked on six remolded and two undisturbed clays, concluded that true cohesion depends only upon the water content of the clay at failure. Crawford (1959) found that cohesive strength of sensitive clays developed to a maximum at an axial compressive strain of less than 1.0 percent, while the friction angle required a much greater strain.

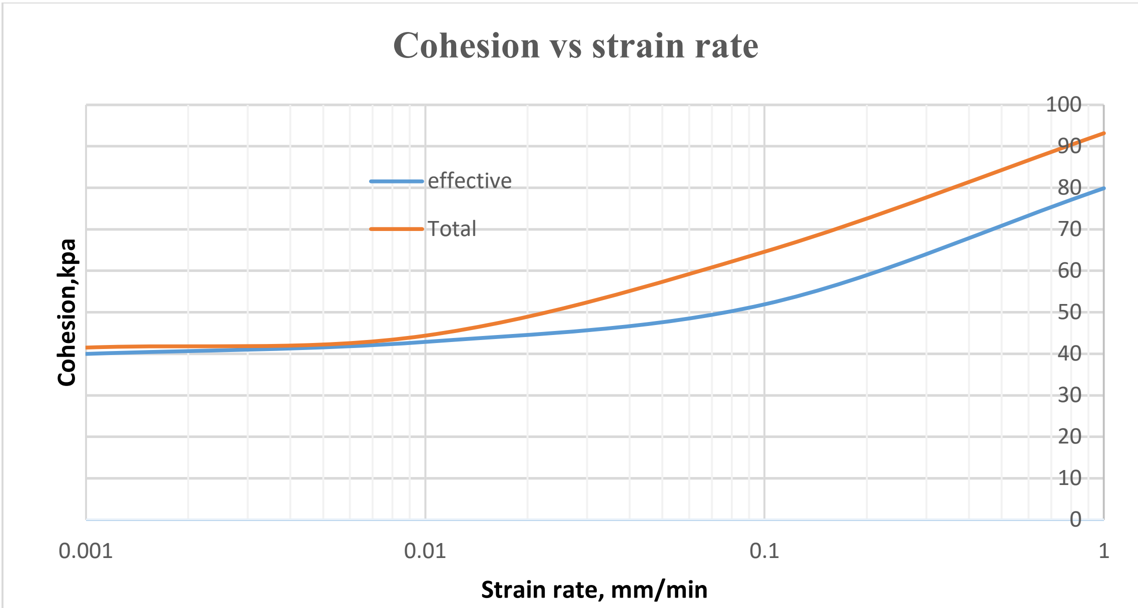


Fig. 4.9. Relationship between cohesion and strain rate

A plot which shows the relationship between cohesion and strain rate in log scale is illustrated in figures 4.9. The graph show strain rate has an impact on cohesion i.e. cohesion increases as strain rate increases but the effect is not as much significant for slow rate (those recommended below BS).

It is known that as moisture content of the soil increases, the cohesion of the soil decreases. In undrained compression test there is local variation of water content with in the triaxial specimens, higher in the middle and lower at the ends. Due to non-uniformity of strain in the specimen. Mitigation of water from the ends towards the center of specimen increases as strain rate increases which is indicated by the decrease in pore water pressure. As a result the cohesion of the soil increases as the strain rate increase.

5 CONCLUSION AND RECOMMENDATION

5.1 Conclusion

In the proceeding chapter, the writer attempted to describe the composition and structure of compacted Asela clay and manner in which the nature of such soil might influence its shear strength characteristics. Consideration of composition indicated that the strength of compacted clay is likely influenced by effective stresses in the soil, pore pressure development, the interparticle spacing at point of contact and rate of strain.

The rate of strain increase as strength (deviator stress) increase and vice-versa. It was also observed in this study of strain rate effect on the strength that strength decreases for slower strain rates. The study clearly demonstrate the findings in this study that as the time failure increases, strength decreases.

Considering the strain at failure, the rates of strain adopted in this study are believed to be sufficiently slow for equalization of pore water pressure at failure. Experimental data revealed that for compacted Asela clay, the excess pore water pressure set up during the process of shearing increased with increased time to failure (slower rate of strain).

The present study also shows the dependence of angle of internal friction (φ') on strain rate. The effective cohesion (c') first attained its maximum value at slower rate of strain and decrease at faster strain rate.

The above conclusion formulated from this study are intended to bring out the importance of strain rate effect on shear strength characteristic of compacted Asela clay.

5.2 Recommendation

For the further research on the strength characteristic of compacted Asela clay, it is recommended that (1) a comprehensive study of the nature of creep and creep strength effects in clays (2) extended on the undisturbed samples for different location of Asela where the clay soil are found. (3) a study of the influence of void ratio at failure on the strength characteristic in terms of effective stress be carried out.

APPENDIX A

Complete Laboratory Tests

Moisture Content Determination

Table A1 Moisture content test for Kebele 09 Pit #1(around chigign mefelfeya)

Location:(chigign mefelfeya)	Job Ref. :		Thesis Research
Soil description ; Red clay soil	Sample No:		#1
Test Method: Oven dry	Depth:		2.8m
Ref. BS 1377; part 2;1990	Date		02/06/2008 EC
specimen Reference			
container no	A	B	
Mass of container (M1)	61	61	
Mass of container + wet soil (m2)	127	118	
Mass of container + dry soil (m3)	112	105	
Mass of moisture (m2-m3)	15	13	
Mass of dry soil (M3-M1)	51	44	
Moisture content w=(m2-m3)/(m3-m1)*100%	29.4	29.5	
Average	29.5		

Table A2 Moisture content test for Kebele 11 Pit #3(around Kenenisa TVET)

Location: around Kenenisa TVET	Job ref.	Thesis research		
	Pit no.	#1		
Soil Description: Red brown clay	Sample no.	#2		
	Depth	3.0m		
Test method: Oven dried, BS 1377-2: 1990: 3.2	Date	02/06/2008E.C		
Container no.	A	B		
Mass of wet soil + container (m2) g	98	109		
Mass of dry soil + container (m3) g	90	98		
Mass of container (m1) g	60	60		
Mass of moisture (m2- m3)g	8	11		
Mass of dry soil (m3- m1)g	30	38		
Moisture content W=(m2-m3)/(m3- m1)*100 %	26.7	28.9		
Average	27.8			

Table A3 Moisture content test for kebele 08 Pit #2 (near Eidgat Besira School)

Location; Asela keb.08 (Idgat besira school)	Job Ref. :		thesis Research
soil description ; Red clay soil	Sample No:		#1
Test Method: ref. BS 1377; part 2;1990	Depth:		3.00m
	Date		27/05/2008 EC
container no	A	B	
Mass of container (M1)	61	62	
Mass of container + wet soil (m2)	121	129	
Mass of container + dry soil (m3)	108	115	
Mass of moisture (m2-m3)	13	14	
Mass of dry soil (M3-M1)	47	53	
Moisture content w=(m2-m3)/(m3-m1)*100%	27.66	26.42	
Average	27.04		

Table A4 Moisture content test for kebele 11 Pit #4 (bale Bar)

Location: Asela kebele 11 specifically Bale Ber		Job ref.	Thesis research	
		Pit no.	#4	
Soil Description: Red clay soil		Sample no.	#1	
		Depth	3.0m	
Test method: Oven dried,BS 1377-2: 1990: 3.2		Date	1/06/2008E.C	
Container no.	A	B		
Mass of wet soil + container (m2) g	97	109		
Mass of dry soil + container (m3) g	88	97		
Mass of container (m1) g	60	60		
Mass of moisture (m2- m3)g	9	12		
Mass of dry soil (m3- m1)g	29	37		
Moisture content = (m2-m3)/(m3- m1)*100 %	31.03	32.43		
Average	31 .73			

Specific Gravity Determination

Table A5 Specific gravity test for pit #1(chigign mefelfeya Area)

Location: Asela kebele 09 (chigign mefelfeya area)	**Job ref.**	**Thesis research**
	Pit no.	**#1**
Soil Description: Red clay soil	**Sample no.**	**#1**
	Depth	**3.0m**
Test method: Small pycnometer BS 1377-2:1990:8.3	**Date**	**11/06/2008E.C**

Specimen ref.	**#1**	**#2**	
Pycnometer number	**1423**	**1424**	
Mass of bottle + soil + water (m3) g	**166**	**166.5**	
Mass of bottle + soil (m2) g	**63**	**63**	
Mass of bottle full of water (m4) g	**159**	**160**	
Mass of bottle (m1) g	**52**	**53**	
Mass of water (m3 – m2) g	**103**	**103.5**	
Mass of soil (m2 – m1) g	**11**	**10**	
Volume of soil particles (m4 – m1) – (m3 – m2) mL	**4**	**3.5**	
Specific Gravity (m2 – m1)/((m4 – m1) – (m3 – m2))	**2.75**	**2.76**	
Average	**2.76**		

Table A6 Specific gravity test for pit #2 (keb.08) Edgat Besira school

Location: Asela keb.08 (edgat besira school area)	**Job ref.**	**Thesis research**
	Pit no.	**#2**
Soil Description: Red clay soil	**Sample no.**	**#1**
	Depth	**3.00m**
Test method: Small pycnometer BS 1377-2:1990:8.3	**Date**	**11/06/2008E.C**

Specimen ref.	**#1**	**#2**	
Pycnometer number	**1426**	**1428**	
Mass of bottle + soil + water (m3) g	**167.5**	**165.3**	
Mass of bottle + soil (m2) g	**62**	**63**	
Mass of bottle full of water (m4) g	**161**	**159**	
Mass of bottle (m1) g	**52**	**53**	
Mass of soil (m2 – m1) g	**10**	**10**	
Mass of water used (m3 – m2) g	**105.2**	**102.3**	
Volume of soil particles (m4 – m1) – (m3 – m2) mL	**3.4**	**3.7**	
Specific Gravity (m2 – m1)/((m4 – m1) – (m3 – m2))	**2.76**	**2.70**	
Average	**2.73**		

Table A7 Specific gravity test for pit #3 around Kenenisa TVET (kebele 11)

Location: Kenennisa TVET area	Job ref.	Thesis research
	Pit no.	#3
Soil Description: Red clay soil	Sample no.	#1
	Depth	2.8m
Test method: Small pyknometer BS 1377-2:1990:8.3	Date	11/06/2008E.C

Specimen ref.	#1	#2	
Pyknometer number	1423	1424	
Mass of bottle + soil + water (m3) g	167.9	167.0	
Mass of bottle + soil (m2) g	64.50	64	
Mass of bottle full of water (m4) g	160.0	160	
Mass of bottle (m1) g	52.0	53	
Mass of soil (m2 – m1) g	12.5	11	
Mass of water in full bottle (m4 – m1) g	108.0	107	
Mass of water used (m3 – m2) g	103.40	103	
Volume of soil particles (m4 – m1) – (m3 – m2) mL	4.60	4	
Specific Gravity (m2 – m1)/((m4 – m1) – (m3 – m2))	2.72	2.75	
Average	2.73		

Table A8 Specific gravity test for Bale Ber pit #4

Location: Bale ber area	Job ref.	Thesis research
	Pit no.	#4
Soil Description: Red clay soil	Sample no.	#1
	Depth	2.5m
Test method: Small pyknometer BS 1377-2:1990:8.3	Date	12/06/2008E.C

Specimen ref.	#1	#2	
Pycnometer number	P14	P52	
Mass of bottle + soil + water (m3) g	153.13	153.34	
Mass of bottle + soil (m2) g	56.42	56.31	
Mass of bottle full of water (m4) g	148.08	149.1	
Mass of bottle (m1) g	48.42	49.58	
Mass of soil (m2 – m1) g	7.99	6.72	
Mass of water in full bottle (m4 – m1) g	99.66	99.51	
Mass of water used (m3 – m2) g	96.71	97.03	
Volume of soil particles (m4 – m1) – (m3 – m2) mL	2.95	2.48	
Specific Gravity (m2 – m1)/((m4 – m1) – (m3 – m2))	2.690	2.690	
Average	2.69		

Free Swell Capacity Determination

Table A9 Free swell test for Kebele 09 pit #1 (chigign mefelfeya)

Location: Kebele 09 (chigign mefelfeya area)	*Job ref.*	*Thesis research*
	Pit no.	*#1*
Soil Description: Red clay soil	*Sample no.*	*#1*
	Depth	*3.00m*
Test method: BS 1377-2:1990:6.4	*Date*	*12/06/2008 E.C*
Test no.	*1*	*2*
Initial Volume, ml	*10.0*	*10.0*
Final Volume, ml	*15.2*	*14.6*
Free Swell, %	*52.0*	*46.0*
Average %	*48.00*	

Table A10 Free swell test for Kebele 08 pit #2 Edgat Besira School

Location: Kebele 08 (edgat besira school area)	*Job ref.*	*Thesis research*
	Pit no.	*#2*
Soil Description: Red clay soil	*Sample no.*	*#1*
	Depth	*3.00m*
Test method: BS 1377-2:1990:6.4	*Date*	*12/06/2008E.C*
Test no.	*1*	*2*
Initial Volume, ml	*10.0*	*10.0*
Final Volume, ml	*13.8*	*14.4*
Free Swell, %	*38*	*44*
Average %	*42*	

Table A11 Free swell test for kenenisa TVET area pit #3

Location: kenenisa Tvet area	*Job ref.*	*Thesis research*
	Pit no.	*#3*
Soil Description: Red clay soil	*Sample no.*	*#1*
	Depth	*2.5m*
Test method: BS 1377-2:1990:6.4	*Date*	*12/06/2008E.C*
Test no.	*1*	*2*
Initial Volume, ml	*10.0*	*10.0*
Final Volume, ml	*14.0*	*13.8*
Free Swell, %	*40.0*	*38.0*
Average %	*39*	

Table A12 Free swell test for Bale bar pit #4

Location: Bale bar area	*Job ref.*	*Thesis research*
	Pit no.	*#4*
Soil Description: Red clay soil	*Sample no.*	*#1*
	Depth	*2.5m*
Test method: BS 1377-2:1990:6.4	*Date*	*12/06/2008E.C*
Test no.	*1*	*2*
Initial Volume, ml	*10.00*	*10.00*
Final Volume, ml	*13.40*	*13.20*
Free Swell, %	*34.00*	*32.00*
Average %	*33*	

Atterberg limits Determination

Table A13 Liquid Limit test for kebele 09 pit #1 (chigign mefelfeya)

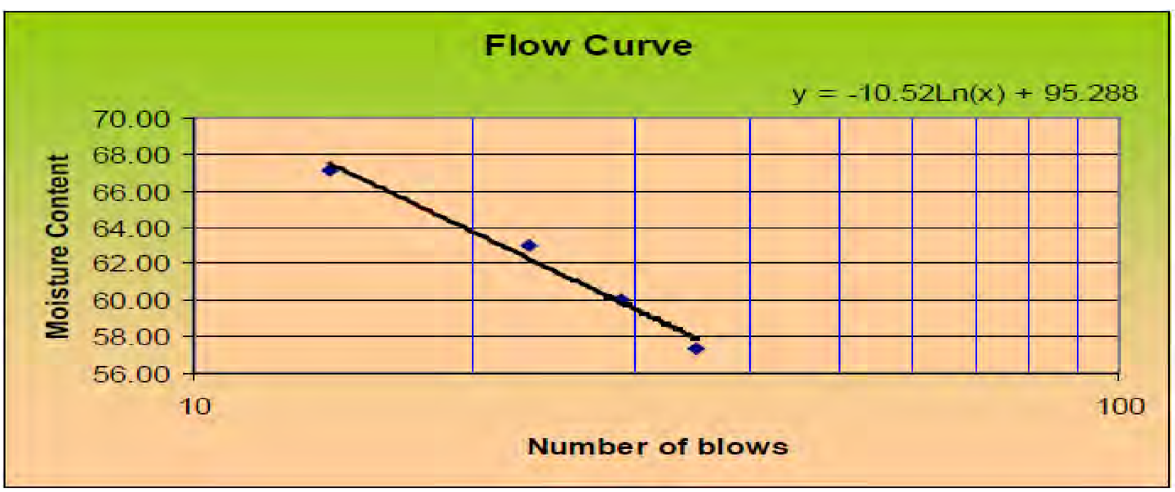
Location: chigign mefelfeya area	***Job ref.***	***Thesis research***
	Pit no.	***#1***
Soil Description: Red brown clay	***Sample no.***	***#1***
	Depth	***3.00m***
Test method: Small pycnometer BS 1377 2:1990:8.3	***Date***	***11/07/2008 E.C***

Plastic Limit test

Test no.	***#1***	***#2***		
Container no.	***D***	***E***		
Mass of wet soil + container (m2) g	***71.00***	***71.00***		
Mass of dry soil + container (m3) g	***68.50***	***69.00***		
Mass of container (m1) g	***61.00***	***61.00***		
Mass of moisture (m2- m3)g	***2.50***	***2.00***		
Mass of dry soil (m3- m1)g	***7.50***	***8.00***		
Moisture content = (m2-m3)/(m3- m1)*100, %	***33.3***	***25.0***		
Average, %	***27.8***			

Liquid Limit test

Test no.	***#1***	***#2***	***#3***	***#4***
Number of blows	***17***	***27***	***31***	***35***
Container no.	***A***	***B***	***C***	***D***
Mass of wet soil + container (m2) g	***71***	***74***	***72.5***	***71***
Mass of dry soil + container (m3) g	***67***	***69***	***68***	***67.5***
Mass of container (m1) g	***61***	***61***	***60***	***61***
Mass of moisture (m2- m3)g	***4***	***5***	***4.5***	***3.5***
Mass of dry soil (m3- m1)g	***6***	***8***	***8***	***6.5***
Moisture content(m2-m3)/(m3- m1)*100, %	***66.7***	***62.5***	***56.3***	***53.3***



LL=-17.41*LN(25)+116.9=60.859	***PL=27.8***	***PI=LL-PL=33.06***	

Table A14 Liquid Limit test for Kebele 08 pit #2 (Eidgat besira school)

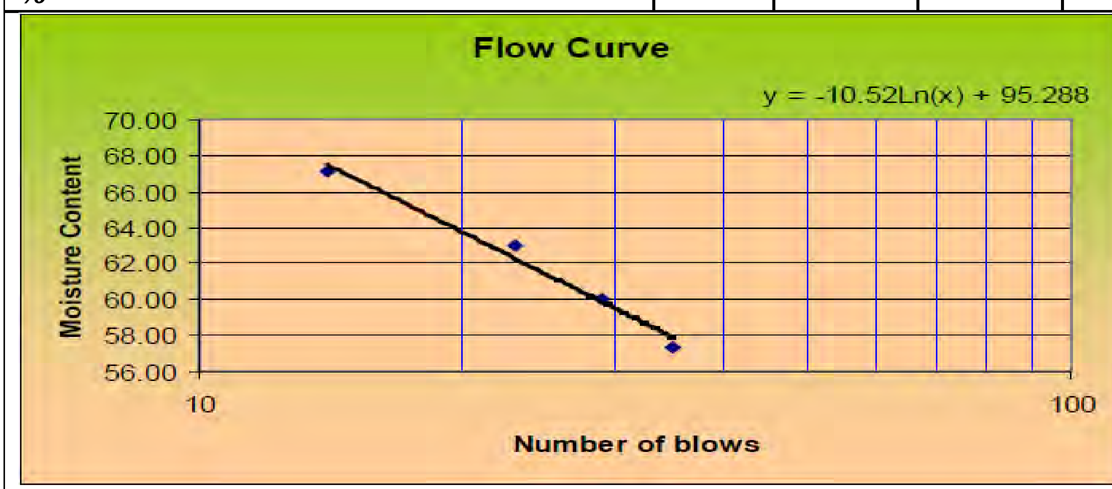
Location: Asela kebele 08 (eidgat besira area)	Job ref.	Thesis research
	Pit no.	#2
Soil Description: Red brown clay	Sample no.	#1
	Depth	3.00m
Test method: Small pycnometer BS 1377-2:1990:8.3	Date	11/07/2008 E.C

Plastic Limit test

Test no.	#1	#2		
Container no.	A	B		
Mass of wet soil + container (m2) g	73.00	71		
Mass of dry soil + container (m3) g	70.50	69		
Mass of container (m1) g	61.00	62.00		
Mass of moisture (m2- m3)g	2.50	2		
Mass of dry soil (m3- m1)g	9.50	7.00		
Moisture content = (m2-m3)/(m3- m1)*100, %	26.3	28.6		
Average, %	27.4			

Liquid Limit test

Test no.	#1	#2	#3	#4
Number of blows	17	23	33	35
Container no.	J	K	L	M
Mass of wet soil + container (m2) g	73.50	74.00	73.00	72.00
Mass of dry soil + container (m3) g	68.50	69.00	69.00	68.00
Mass of container (m1) g	61.00	61.00	62.00	60.00
Mass of moisture (m2- m3)g	5.00	5.00	4.00	4.00
Mass of dry soil (m3- m1)g	7.50	8.00	7.00	8.00
Moisture content(m2-m3)/(m3- m1)*100, %	66.70	62.50	57.10	50.00



LL=-19.97*LN(25)+124.08=59.8	PL=27.4	PI=LL-PL=32.4	

Table A15 Liquid Limit test for kebele 11(Around Kenenisa TVET) pit #3

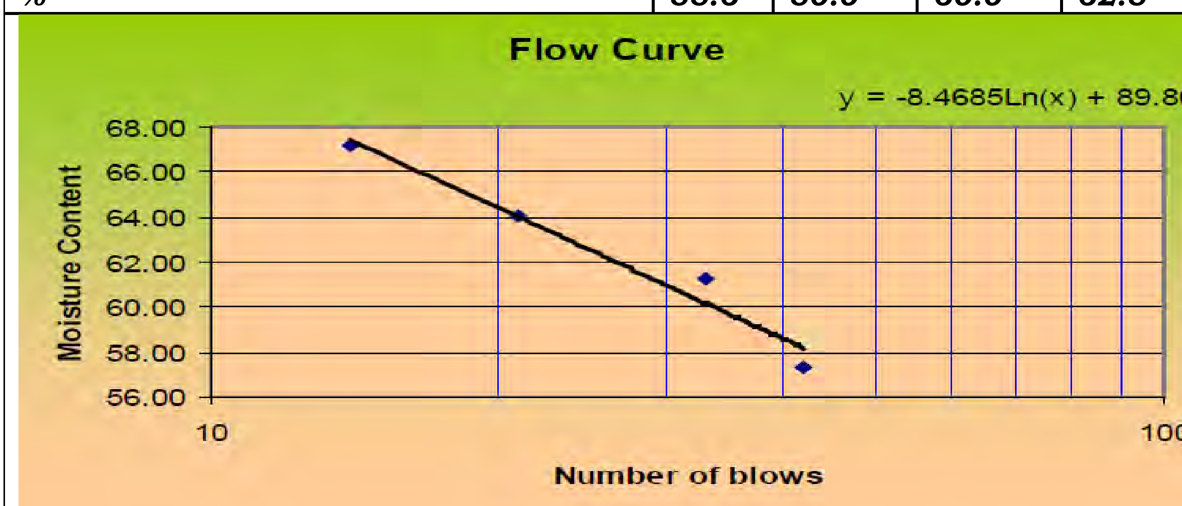
Location: Around kenenisa TVET area	**Job ref.**	**Thesis research**
	Pit no.	**#1**
Soil Description: Red brown clay	**Sample no.**	**#1**
	Depth	**2.8m**
Test method: Small pyknometer BS 1377-2:1990:8.3	**Date**	**21/07/2008 E.C**

Plastic Limit test

Test no.	#1	#2		
Container no.	F	G2		
Mass of wet soil + container (m2) g	74.00	75		
Mass of dry soil + container (m3) g	71.50	72		
Mass of container (m1) g	62.00	61.00		
Mass of moisture (m2- m3)g	2.50	3		
Mass of dry soil (m3- m1)g	9.50	11.00		
Moisture content = (m2-m3)/(m3- m1)*100, %	26.3	27.3		
Average, %	26.8			

Liquid Limit test

Test no.	#1	#2	#3	#4
Number of blows	28	33	23	17
Container no.	A	B	C	D
Mass of wet soil + container (m2) g	75.00	73.00	74.00	74.00
Mass of dry soil + container (m3) g	70.00	69.00	69.50	69.00
Mass of container (m1) g	61.00	61.00	62.00	61.00
Mass of moisture (m2- m3)g	5.00	4.00	4.50	5.00
Mass of dry soil (m3- m1)g	9.00	8.00	7.50	8.00
Moisture content(m2-m3)/(m3- m1)*100, %	55.6	50.0	60.0	62.5



LL =-18.34*LN(25)+115.7=63	PL=26.8	PI=LL-PL=35.2	

Table A16 Liquid Limit test for Bale Ber pit #4

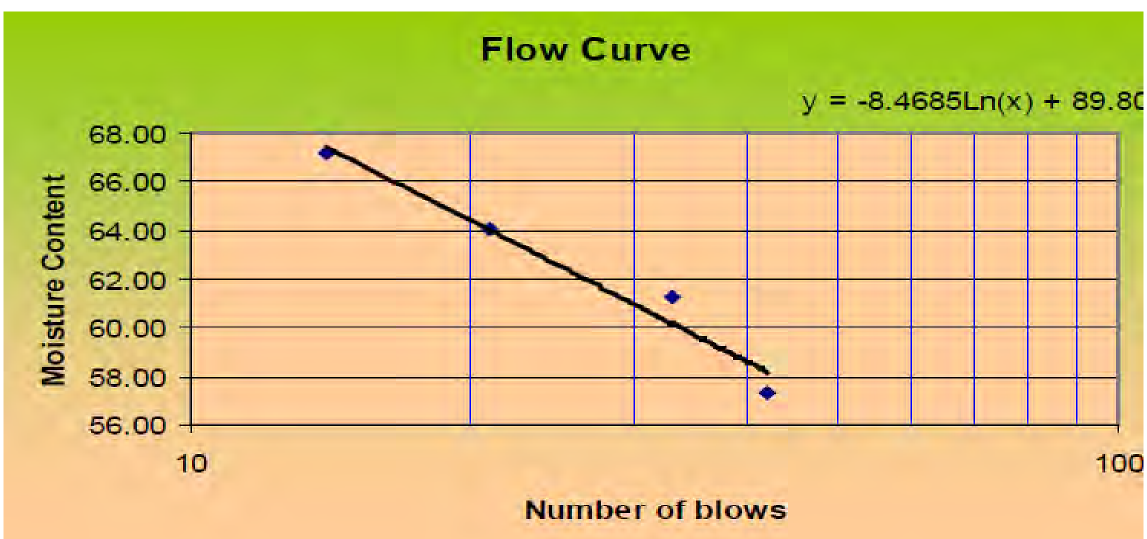
Location: ***bale ber area***	***Job ref.***	***Thesis research***
	Pit no.	***#2***
Soil Description: ***Red brown clay***	***Sample no.***	***#1***
	Depth	***2.8m***
Test method: Small pyknometer BS 1377-2:1990:8.3	***Date***	***11/07/2008E.C***

Plastic Limit test

Test no.	***#1***	***#2***		
Container no.	***BZ***	***AZ***		
Mass of wet soil + container (m2) g	***71***	***78.00***		
Mass of dry soil + container (m3) g	***69***	***74***		
Mass of container (m1) g	***62.00***	***60.00***		
Mass of moisture (m2- m3)g	***2***	***4***		
Mass of dry soil (m3- m1)g	***7.00***	***14.00***		
Moisture content = (m2-m3)/(m3- m1)*100, %	***28.6***	***28.6***		
Average, %	***28.6***			

Liquid Limit test

Test no.	***#1***	***#2***	***#3***	***#4***
Number of blows	***17***	***23***	***33***	***35***
Container no.	***x***	***y***	***z***	***Z2***
Mass of wet soil + container (m2) g	***74.00***	***74.00***	***73.00***	***72.00***
Mass of dry soil + container (m3) g	***69.00***	***69.00***	***69.00***	***68.00***
Mass of container (m1) g	***62.00***	***61.00***	***62.00***	***60.00***
Mass of moisture (m2- m3)g	***5.00***	***5.00***	***4.00***	***4.00***
Mass of dry soil (m3- m1)g	***7.00***	***8.00***	***7.00***	***8.00***
Moisture content(m2-m3)/(m3- m1)*100, %	***71.4***	***62.5***	***57.1***	***50.0***



LL =-25.87*LN(25)+144.46=61.2	***PL= 28.6***	***PI=LL-PL=33***	

Particle Size Analysis

Table A17 Hydrometer test for kebele 09 pit #1(chigign mefelfeya)

Location: Asela kebele 09 chigign mefelfeye area	***Job ref.***	***Thesis research***
	Pit no.	***#1***
Soil Description: Red brown clay	***Sample no.***	***#1***
	Depth	***3.00m***
Test method: Hydrometer, ASTM D 422-63	***Date***	***25/07/2008 E.C***
	Specific Gravity	***2.80***
Lab Temperature: 20 degree centigrade	***Composite correction***	***-0.0027***
	K Value	***0.01336***

Elapsed Time (min)	***Actual Hydrometer Reading***	***Composite Correction***	***Corrected Hydrometer Reading***	***Effective Depth (cm)***	***Coefficient K***	***Grain Size (mm)***	***Perc. Finer (%)***
1	1.0260	-0.0027	1.0233	9.42	0.01336	0.0430	73.79
2	1.0240	-0.0027	1.0213	9.95	0.01336	0.0298	66.37
4	1.0230	-0.0027	1.0203	10.22	0.01336	0.0214	63.80
8	1.0200	-0.0027	1.0173	11.01	0.01336	0.0157	56.72
15	1.0180	-0.0027	1.0153	11.54	0.01336	0.0117	49.41
30	1.0150	-0.0027	1.0123	12.33	0.01336	0.0086	39.04
60	1.0130	-0.0027	1.0103	12.86	0.01336	0.0062	33.08
120	1.0110	-0.0027	1.0083	13.39	0.01336	0.0045	27.21
240	1.0090	-0.0027	1.0063	13.92	0.01336	0.0032	20.23
1140	1.0060	-0.0027	1.0033	14.71	0.01336	0.0015	10.52
1440	1.0060	-0.0027	1.0033	14.71	0.01336	0.0014	10.52

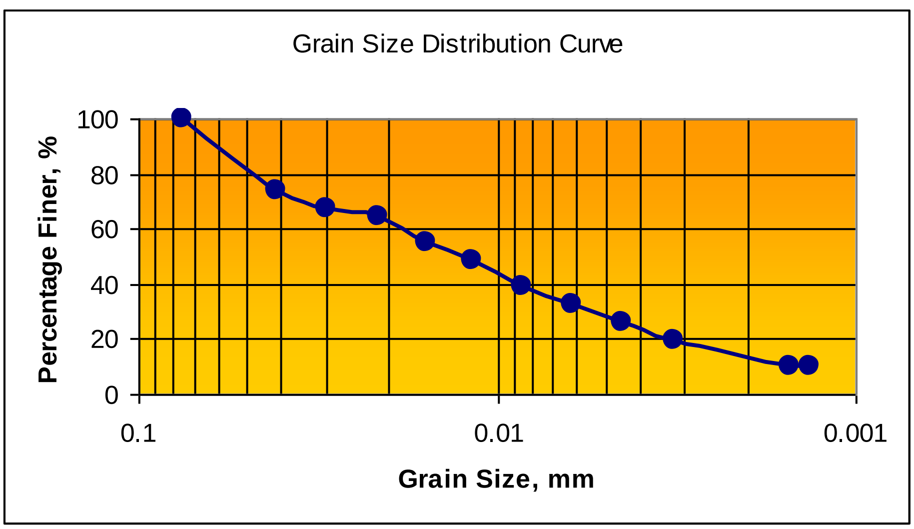


Table A18 Hydrometer test for Edgat besira school pit #2

Location: Asela keb,08 Edgat Besira school area	***Job ref.***	***Thesis research***
	Pit no.	***#2***
Soil Description: Red brown clay	***Sample no.***	***#1***
	Depth	***2.5m***
Test method: Hydrometer, ASTM D 422-63	***Date***	***25/07/2008 E.C***
	Specific Gravity	***2.78***
Lab Temperature: 20 degree centigrade	***Composite correction***	***-0.0027***
	K Value	***0.01333***

Elapsed Time (min)	***Actual Hydrometer Reading***	***Composite Correction***	***Corrected Hydrometer Reading***	***Effective Depth (cm)***	***Coefficient K***	***Grain Size (mm)***	***Perc. Finer (%)***
1	1.0270	-0.0027	1.0243	9.16	0.01333	0.0403	77.14
2	1.0250	-0.0027	1.0223	9.69	0.01333	0.0293	71.31
4	1.0230	-0.0027	1.0203	10.22	0.01333	0.0213	65.07
8	1.0210	-0.0027	1.0183	10.75	0.01333	0.0154	57.67
15	1.0190	-0.0027	1.0163	11.27	0.01333	0.0116	51.11
30	1.0170	-0.0027	1.0143	11.80	0.01333	0.0084	46.17
60	1.0150	-0.0027	1.0123	12.33	0.01333	0.0060	39.90
120	1.0140	-0.0027	1.0113	12.60	0.01333	0.0043	33.88
240	1.0120	-0.0027	1.0093	13.13	0.01333	0.0031	30.35
1150	1.0100	-0.0027	1.0073	13.65	0.01333	0.0015	22.00
1440	1.0100	-0.0027	1.0073	13.65	0.01333	0.0013	23.00

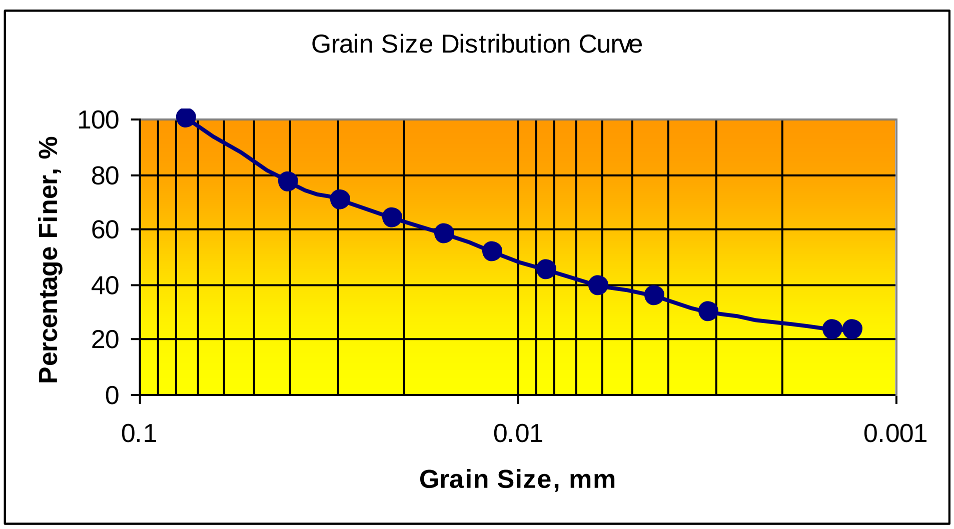


Table A19 Hydrometer test for kebele 11 pit #1(kenenisa TVET Area)

Location: Kenenisa TVET school area	***Job ref.***	***Thesis research***
	Pit no.	***#1***
Soil Description: Red brown clay	***Sample no.***	***#1***
	Depth	***2.5m***
Test method: Hydrometer, ASTM D 422-63	***Date***	***25/07/2008 E.C***
	Specific Gravity	***2.73***
Lab Temperature: 20 degree centigrade	***Composite correction***	***-0.0027***
	K Value	***0.01340***

Elapsed Time (min)	***Actual Hydrometer Reading***	***Composite Correction***	***Corrected Hydrometer Reading***	***Effective Depth (cm)***	***Coefficient K***	***Grain Size (mm)***	***Perc. Finer (%)***
0.5	***1.0330***	***-0.0027***	***1.0303***	***7.57***	***0.01340***	***0.0522***	***96.04***
1	***1.0315***	***-0.0027***	***1.0288***	***7.97***	***0.01340***	***0.0378***	***91.28***
2	***1.0305***	***-0.0027***	***1.0278***	***8.23***	***0.01340***	***0.0272***	***88.11***
4	***1.0300***	***-0.0027***	***1.0273***	***8.36***	***0.01340***	***0.0194***	***86.53***
8	***1.0295***	***-0.0027***	***1.0268***	***8.50***	***0.01340***	***0.0138***	***84.95***
15	***1.0285***	***-0.0027***	***1.0258***	***8.76***	***0.01340***	***0.0102***	***81.78***
30	***1.0275***	***-0.0027***	***1.0248***	***9.03***	***0.01340***	***0.0074***	***78.61***
60	***1.0265***	***-0.0027***	***1.0238***	***9.29***	***0.01340***	***0.0053***	***75.44***
120	***1.0250***	***-0.0027***	***1.0223***	***9.69***	***0.01340***	***0.0038***	***70.68***
240	***1.0245***	***-0.0027***	***1.0218***	***9.82***	***0.01340***	***0.0027***	***69.10***
480	***1.0225***	***-0.0027***	***1.0198***	***10.35***	***0.01340***	***0.0020***	***62.76***
1440	***1.0220***	***-0.0027***	***1.0193***	***10.48***	***0.01340***	***0.0011***	***61.17***

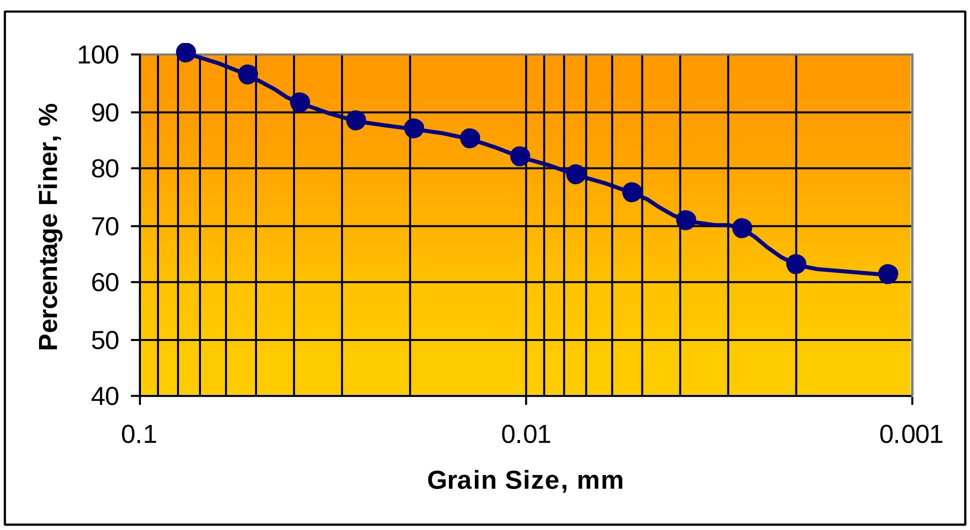
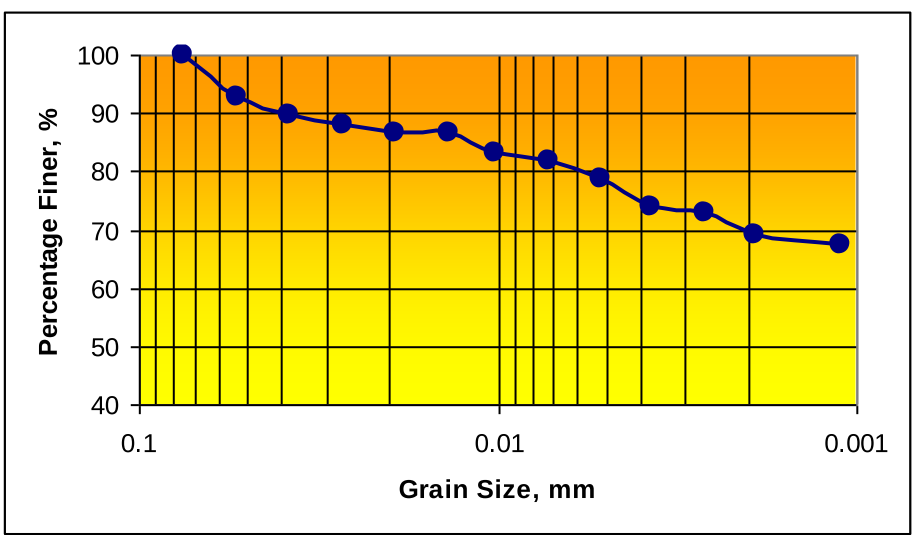


Table A20 Hydrometer test for Bale ber pit #4

Location: Bale ber area	*Job ref.*	*Thesis research*
	Pit no.	*#4*
Soil Description: Red brown clay	*Sample no.*	*#1*
	Depth	*2.5m*
Test method: Hydrometer, ASTM D 422-63	*Date*	*25/07/2008 E.C*
	Specific Gravity	*2.69*
Lab Temperature: 20 degree centigrade	*Composite correction*	*-0.0027*
	K Value	*0.01340*

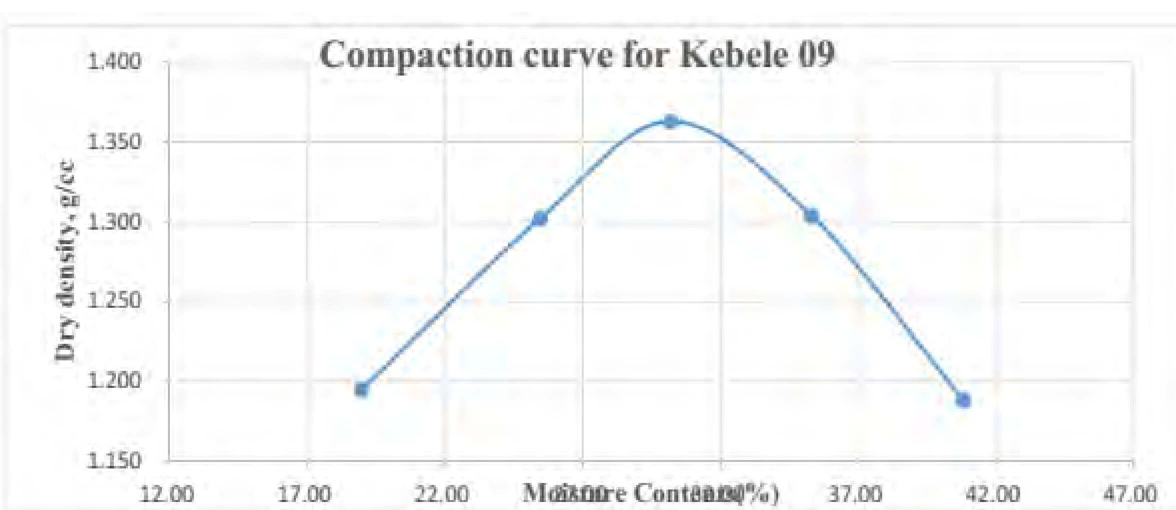
Elapsed Time (min)	*Actual Hydrometer Reading*	*Composite Correction*	*Corrected Hydrometer Reading*	*Effective Depth (cm)*	*Coefficient K*	*Grain Size (mm)*	*Perc. Finer (%)*
0.5	1.0320	-0.0027	1.0293	7.84	0.01340	0.0531	92.87
1	1.0310	-0.0027	1.0283	8.10	0.01340	0.0381	89.70
2	1.0305	-0.0027	1.0278	8.23	0.01340	0.0272	88.11
4	1.0300	-0.0027	1.0273	8.36	0.01340	0.0194	86.53
8	1.0300	-0.0027	1.0273	8.36	0.01340	0.0137	86.53
15	1.0290	-0.0027	1.0263	8.63	0.01340	0.0102	83.36
30	1.0285	-0.0027	1.0258	8.76	0.01340	0.0072	81.78
60	1.0275	-0.0027	1.0248	9.03	0.01340	0.0052	78.61
120	1.0260	-0.0027	1.0233	9.42	0.01340	0.0038	73.85
240	1.0258	-0.0027	1.0231	9.49	0.01340	0.0027	73.06
480	1.0245	-0.0027	1.0218	9.82	0.01340	0.0019	69.10
1440	1.0240	-0.0027	1.0213	9.95	0.01340	0.0011	67.51



Compaction Test

Table A21 Standard compaction test for Kebele 9 (chigign mefelfeya) pit #1

Location: chigign mefelfeya (keb. 09)		Job ref.		Thesis research	
		Pit no.		#1	
Soil Description: Red clay soil		Sample no.		#1	
		Depth		3.00m	
Test method: Standard Compaction ASTM D 698-91		Date		1/07/2008E.C	
Blows/layer	25	No.of layers	3	Wt of hammer, Kg	2.5
Mold dia, cm	10.16	Mold Ht,	12	Vol, cc	972.88
Water Content Determination					
Determination No	1	2	3	4	5
Container No	A	B	G	F	I
Mass of Container, M1 ,g	61	61	61	61	61
Mass of Container + Wet Soil, M2	130	130	130	130	130
Mass of Container + Dry Soil, M3	119	116	114	112	110
Mass of Water, M2-M3 ,g	11	14	16	18	20
Mass of Dry Soil, M3-M1 ,g	58	55	53	51	49
Moisture Content,	18.97	25.45	30.19	35.29	40.82
Density Determination					
Water content. Wo, %	18.97	25.45	30.19	35.3	40.82
Wt of soil + mold, g	5791	5928	6134	6124	6036
Wt of mold, g	4408	4408	4408	4408	4408
Wt of soil in mold, g	1385	1520	1726	1716	1628
Wet density, g/cc	1.42	1.562	1.774	1.76	1.71
Dry density, g/cc	1.195	1.245	1.363	1.3	1.188

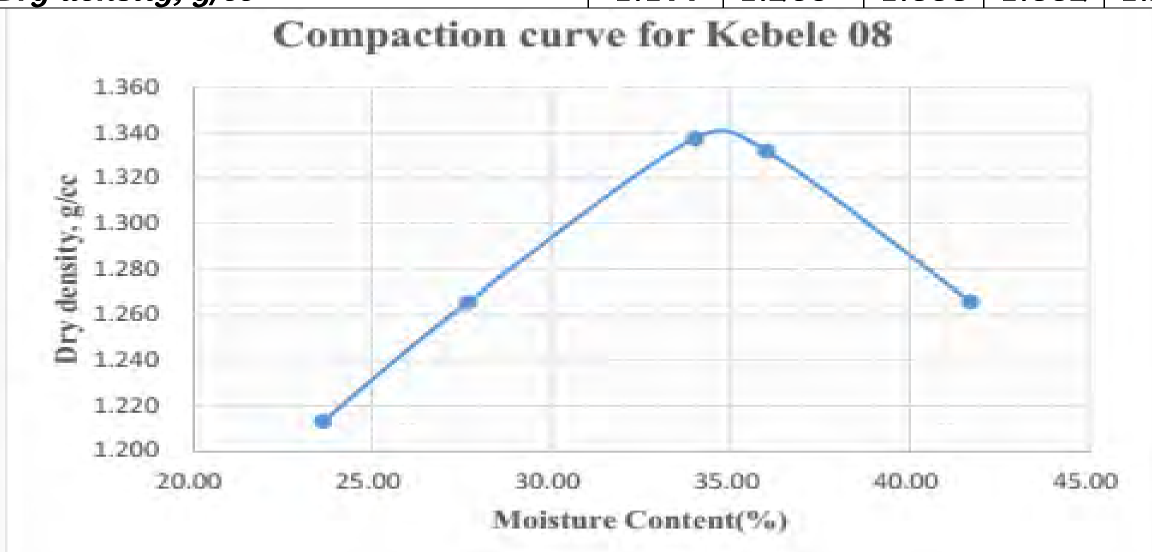


Optimum moisture Content	30%	Maximum Dry Density	1.36 g/cc

Table A22 Standard compaction test for Kebele 08(Idgat Besira School) pit #2

Location: Eidgat Besira school		**Job ref.**	**Thesis research**		
		Pit no.	**#2**		
Soil Description: Red clay soil		**Sample no.**	**#1**		
		Depth	**2.5m**		
Test method: Standard Compaction, ASTM D 698-91		**Date**	**15/07/2008E.C**		
Blows/layer	**25**	**No. of layers**	**3**	**Wt of hammer, Kg**	**2.5**
Mold dia, cm	**10.16**	**Mold Ht, cm**	**12**	**Vol, CC**	**972.88**

Water Content Determination					
Determination No	**1**	**2**	**3**	**4**	**5**
Container No	**A**	**B**	**C**	**D**	**FF**
Mass of Container, M1 ,g	**61**	**61**	**61**	**61**	**61**
Mass of Container + Wet Soil, M2 ,g	**129**	**121**	**128**	**129**	**129**
Mass of Container + Dry Soil, M3 ,g	**116**	**108**	**111**	**111**	**109**
Mass of Water, M2-M3 ,g	**13**	**13**	**17**	**18**	**20**
Mass of Dry Soil, M3-M1 ,g	**55**	**47**	**50**	**50**	**48**
Moisture Content, W=(M2-M3)/(M3-M1)*100, %	**23.64**	**27.66**	**34**	**36**	**41**
Density Determination					
Water content. Wo, %	**23.64**	**27.66**	**34**	**36**	**41**
Wt. of soil + mold, g	**5824**	**5933**	**6100**	**6118**	**6101**
Wt. of mold, g	**4408**	**4408**	**4408**	**4408**	**4408**
Wt. of soil in mold, g	**1416**	**1525**	**1692**	**1710**	**1693**
Wet density, g/cc	**1.455**	**1.615**	**1.792**	**1.811**	**1.79**
Dry density, g/cc	**1.177**	**1.265**	**1.338**	**1.332**	**1.26**

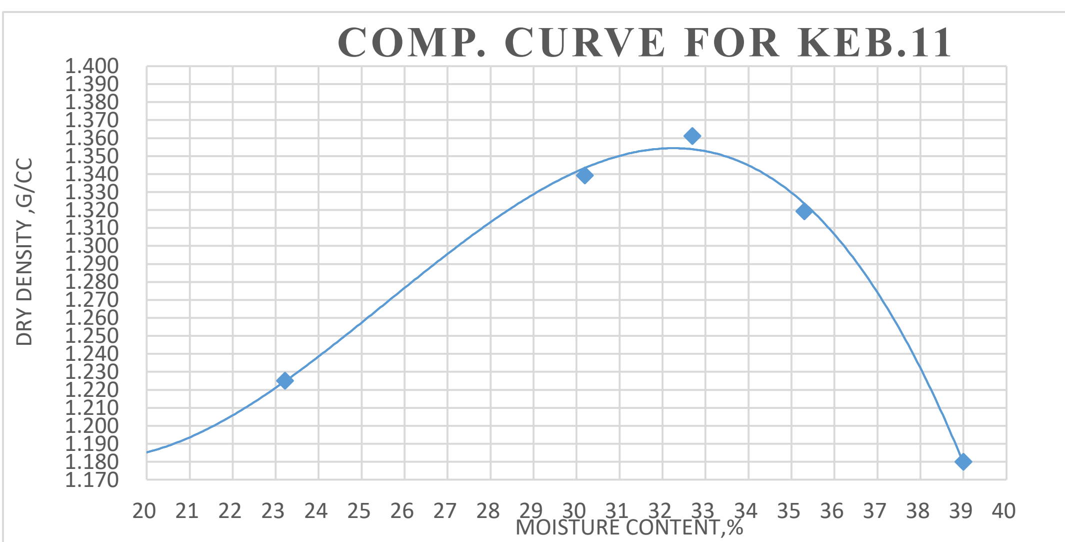


Optimum moisture Content	**34%**	**Maximum Dry Density**	**1.34 g/cc**

Table A23 Standard compaction test for kenenesa TVET area #3

Location: Kenenisa Tvet area			Job ref.	Thesis research	
			Pit no.	#1	
Soil Description: Red clay soil			Sample no.	#1	
			Depth	2.90 m	
Test method: Standard Compaction, ASTM D 698-91			Date	15/07/2008E.C	
Blows/layer	25	No. of layers	3	Wt of hammer, Kg	2.5
Mold dia, cm	10.16	Mold Ht, cm	12	Vol, CC	944

Water Content Determination					
Determination No	1	2	3	4	5
Container No	E	F	G	H	HE
Mass of Container, M1 ,g	61	61	61	61	61
Mass of Container + Wet Soil, M2 ,g	130	130	130	130	130
Mass of Container + Dry Soil, M3 ,g	121	117	114	113	112
Mass of Water, M2-M3 ,g	9	13	16	17	18
Mass of Dry Soil, M3-M1 ,g	60	56	53	52	51
Moisture Content, W=(M2-M3)/(M3-M1)*100, %	16.01	23.21	30.19	32.69	35.29
Density Determination					
Water content. Wo, %	16.01	23.21	30.19	32.69	35.29
Wt of soil + mold, g	5731	5833	6054	6113	6093
Wt of mold, g	4408	4408	4408	4408	4408
Wt of soil in mold, g	1323	1425	1646	1705	1685
Wet density, g/cc	1.401	1.510	1.744	1.806	1.785
Dry density, g/cc	1.208	1.225	1.339	1.361	1.319



Optimum moisture Content	32.5%	Maximum Dry Density	1.36 g/cc

Table A24 Standard compaction test for Bale ber area pit#4

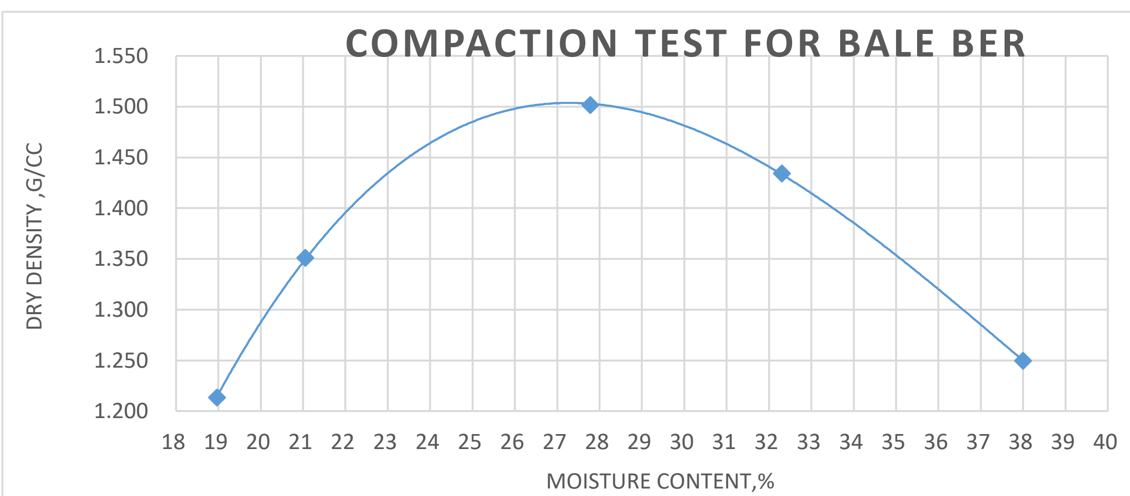
Location: Bale Ber area				Job ref.	Thesis research		
				Pit no.	#4		
Soil Description: Red brown clay				Sample no.	#1		
				Depth	2.5m		
Test method: Standard Compaction, ASTM D 698-91				Date	23/06/2008 E.C		
Blows/layer	25	No. of layers	3	Wt of hammer, Kg	2.5		
Mold dia, cm	10.16	Mold Ht, cm	12	Vol, CC	972.88		

Water Content Determination

Determination No	1	2	3	4	5
Container No	G	H	HH	J	I
Mass of Container, M1 ,g	61	61	61	61	61
Mass of Container + Wet Soil, M2 ,g	130	130	130	130	130
Mass of Container + Dry Soil, M3 ,g	119	118	115	113	111
Mass of Water, M2-M3 ,g	11	12	15	16.8	19
Mass of Dry Soil, M3-M1 ,g	58	57	54	52	50
Moisture Content, W=(M2-M3)/(M3-M1)*100, %	18.97	21.05	27.78	32.21	38.00

Density Determination

Water content. Wo, %	18.97	21.05	27.78	32.21	38.00
Wt of soil + mold, g	6000	6212	6524	6501	6310
Wt of mold, g	4408	4408	4408	4408	4408
Wt of soil in mold, g	1592	1804	2116	2093	1902
Wet density, g/cc	1.443	1.636	1.918	1.898	1.724
Dry density, g/cc	1.213	1.351	1.501	1.434	1.250



Optimum moisture Content	27.5%	Maximum Dry Density	1.51 g/cc

APPENDIX B
UNCONFINED COMPRESSION STRENGTH TEST RESULT

Table B1: Unconfined compression strength test result for Asela kebele 09 under the strain rate of 0.08mm/min

Length(mm)	76		strain Rate (mm/min)		0.08
Diameter (mm)	38		sample number		#1
Area(m2)	0.001134115		sample type		Remolded
project area	kebele 09		Depth		3.00m
Def.mm	Strain (%)	R3=1-strain	Load in N	corrected area=Ao/R3	stress (kPa)=P/Ac
0	0	1	0	0.001134115	0.000
0.001	0.001315789	0.999986842	12	0.00113413	10.567
0.005	0.006578947	0.999934211	20	0.00113419	17.519
0.01	0.013157895	0.999868421	31	0.001134264	27.082
0.025	0.032894737	0.999671053	44	0.001134488	38.337
0.151	0.198684211	0.998013158	46	0.001136373	39.973
0.303	0.398684211	0.996013158	51	0.001138655	44.200
0.349	0.459210526	0.995407895	53	0.001139347	45.810
0.388	0.510526316	0.994894737	54	0.001139935	46.549
0.462	0.607894737	0.993921053	58	0.001141051	49.863
0.568	0.747368421	0.992526316	60	0.001142655	51.443
0.697	0.917105263	0.990828947	63	0.001144612	53.869
0.83	1.092105263	0.989078947	66	0.001146637	56.281
0.922	1.213157895	0.987868421	66	0.001148043	56.128
1.126	1.481578947	0.985184211	68	0.00115117	57.671
1.389	1.827631579	0.981723684	72	0.001155228	60.896
1.5	1.973684211	0.980263158	74	0.00115695	62.416
1.601	2.106578947	0.978934211	80	0.00115852	67.291
2.5	3.289473684	0.967105263	81	0.00117269	68.038
3	3.947368421	0.960526316	82	0.001180722	67.013
3.4	4.473684211	0.955263158	82	0.001187228	66.920
3	3.947368421	0.960526316	79	0.001180722	65.992
3.501	4.606578947	0.953934211	74	0.001188882	61.729
4.01	5.276315789	0.947236842	68	0.001197288	56.645
4.5	5.921052632	0.940789474	64	0.001205493	53.090
5.01	6.592105263	0.934078947	61	0.001214153	50.177
5.5	7.236842105	0.927631579	60	0.001222592	49.076
6.028	7.931578947	0.920684211	54	0.001231818	43.838
8.25	10.85526316	0.891447368	52	0.001272218	40.874
9.5	12.5	0.875	47	0.001296131	36.262
10.5	13.81578947	0.861842105	45	0.00131592	34.197
12.5	16.44736842	0.835526316	42	0.001357366	30.942

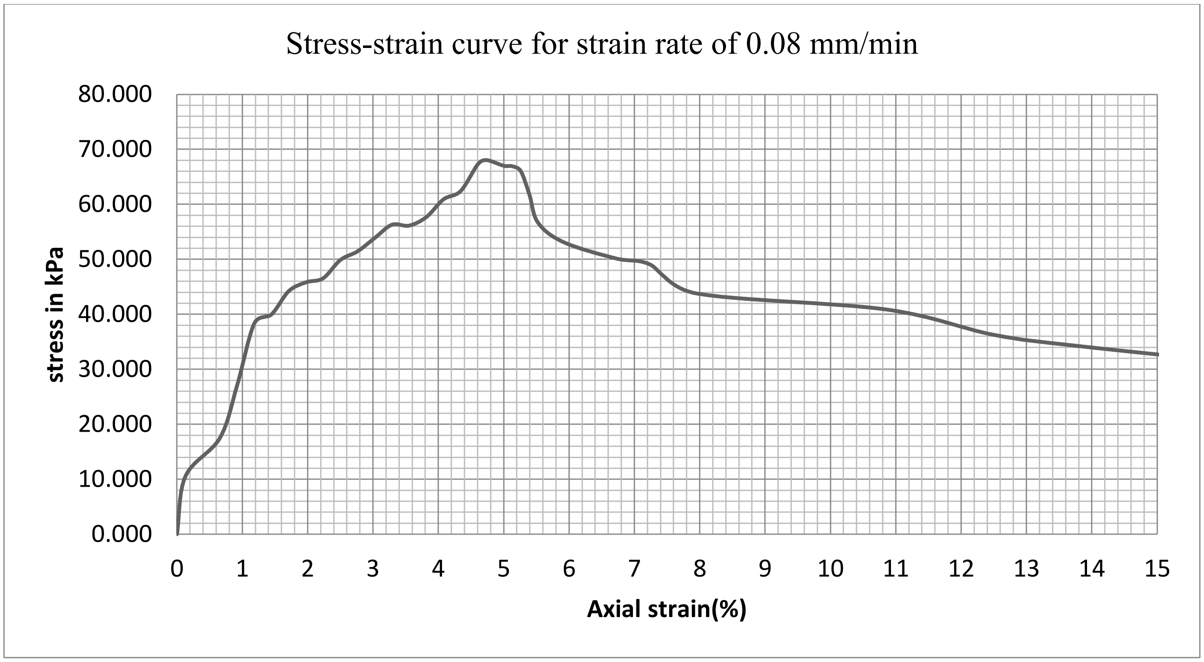


Fig.B1. unconfined compressive strength of Asela keb. 09 for strain rate of 0.08mm/min (68.04kPa)

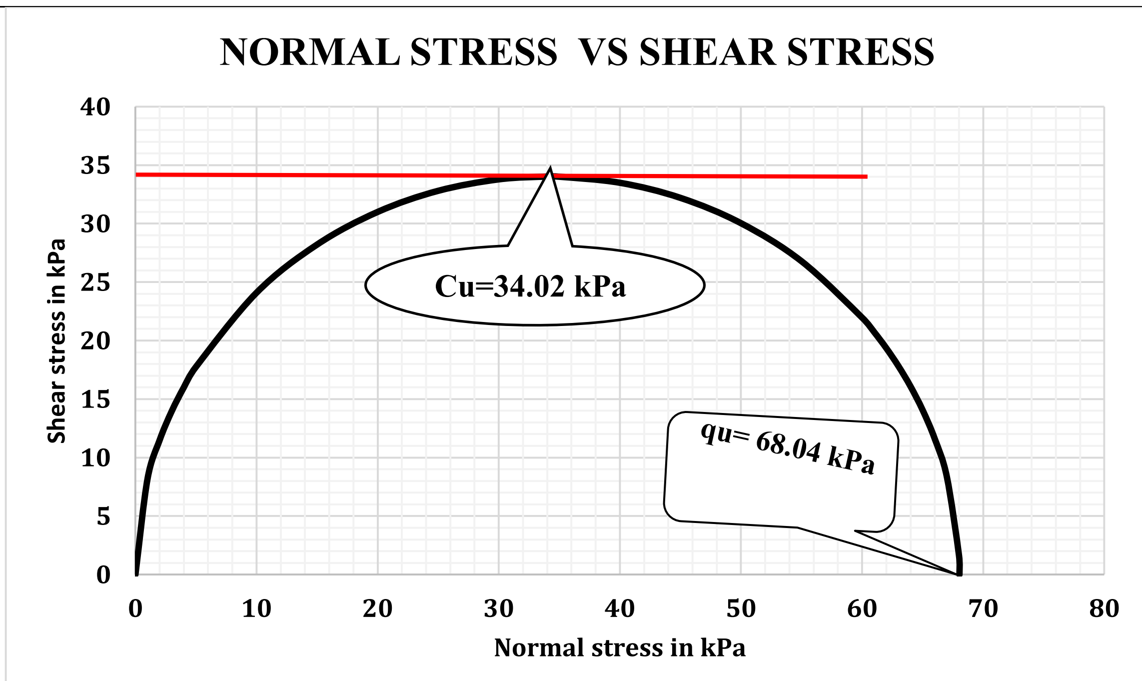


Fig B2. Mohr's circle for Unconfined compressive strength for strain rate of 0.08mm/min

Unconfined compression strength, Qu	**68.04 kPa**
Undrained shear strength, su	**34.02 kPa**

Table B2: Unconfined compression strength test result for Asela kebele 09 with the strain rate of 0.4mm/min

Length(mm)	76		strain Rate (mm/min)		0.40
Diameter (mm)	38		sample number		#1
Area(m2)	0.001134115		sample type		Remolded
project area	kebele 09		Depth		3.00m
Def.mm	Strain (%)	R3=1-strain	Load in N	corrected area=Ao/R3	stress (kPa)=P/Ac
0.001	0.001316	0.99998684	10.00	0.00113413	8.817
0.005	0.006579	0.99993421	20.00	0.00113419	17.634
0.010	0.013158	0.99986842	41.00	0.00113426	36.147
0.020	0.026316	0.99973684	46.00	0.00113441	40.550
0.024	0.031579	0.99968421	53.00	0.00113447	46.718
0.025	0.032895	0.99967105	54.00	0.00113449	47.599
0.151	0.198684	0.99801316	56.00	0.00113637	49.280
0.303	0.398684	0.99601316	61.00	0.00113865	53.572
0.349	0.459211	0.99540789	63.00	0.00113935	55.295
0.388	0.510526	0.99489474	64.00	0.00113993	56.144
0.462	0.607895	0.99392105	68.00	0.00114105	59.594
0.515	0.677632	0.99322368	70.00	0.00114185	61.304
0.568	0.747368	0.99252632	71.00	0.00114265	62.136
0.697	0.917105	0.99082895	73.00	0.00114461	63.777
0.830	1.092105	0.98907895	75.00	0.00114664	65.409
0.922	1.213158	0.98786842	76.00	0.00114804	66.200
1.126	1.481579	0.98518421	78.00	0.00115117	67.757
1.389	1.827632	0.98172368	80.00	0.00115523	69.250
1.500	1.973684	0.98026316	81.00	0.00115695	70.012
1.601	2.106579	0.97893421	83.00	0.00115852	71.643
2.500	3.289474	0.96710526	85.00	0.00117269	72.483
3.000	3.947368	0.96052632	86.00	0.00118072	72.837
3.400	4.473684	0.95526316	86.00	0.00118723	72.438
3.000	3.947368	0.96052632	85.00	0.00118072	71.990
3.501	4.606579	0.95393421	78.00	0.00118888	65.608
4.010	5.276316	0.94723684	70.00	0.00119729	58.465
4.500	5.921053	0.94078947	66.00	0.00120549	54.749
5.010	6.592105	0.93407895	64.00	0.00121415	52.712
5.500	7.236842	0.92763158	61.00	0.00122259	49.894
6.028	7.931579	0.92068421	54.00	0.00123182	43.838
8.250	10.855263	0.89144737	52.00	0.00127222	40.874
9.500	12.500000	0.875	50.00	0.00129613	38.576
10.500	13.815789	0.86184211	47.00	0.00131592	35.716
12.500	16.447368	0.83552632	44.00	0.00135737	32.416

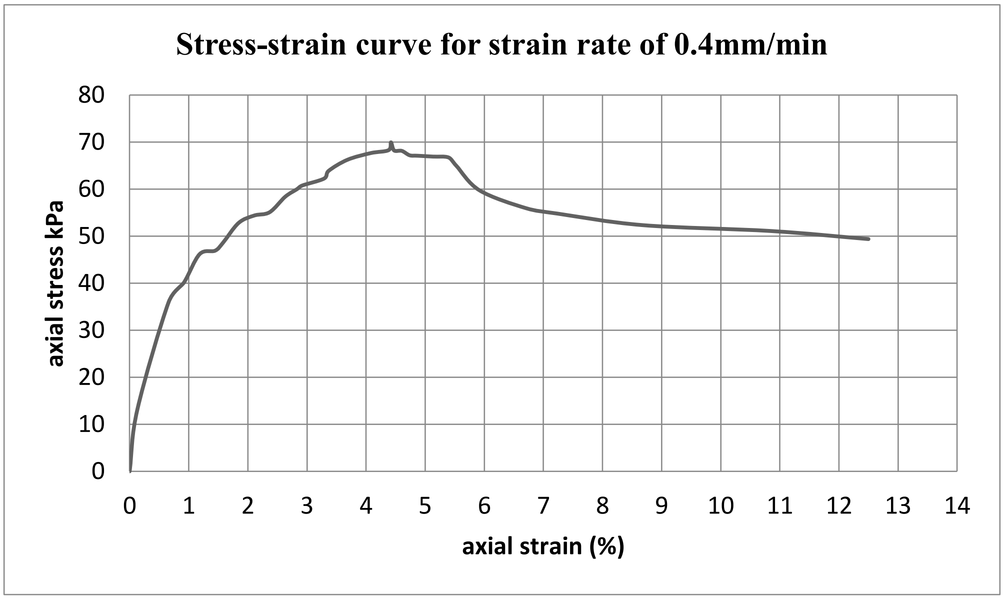


Fig.B3 unconfined compressive strength of Asela keb. 09 for strain rate of 0.4mm/min (72.90kPa)

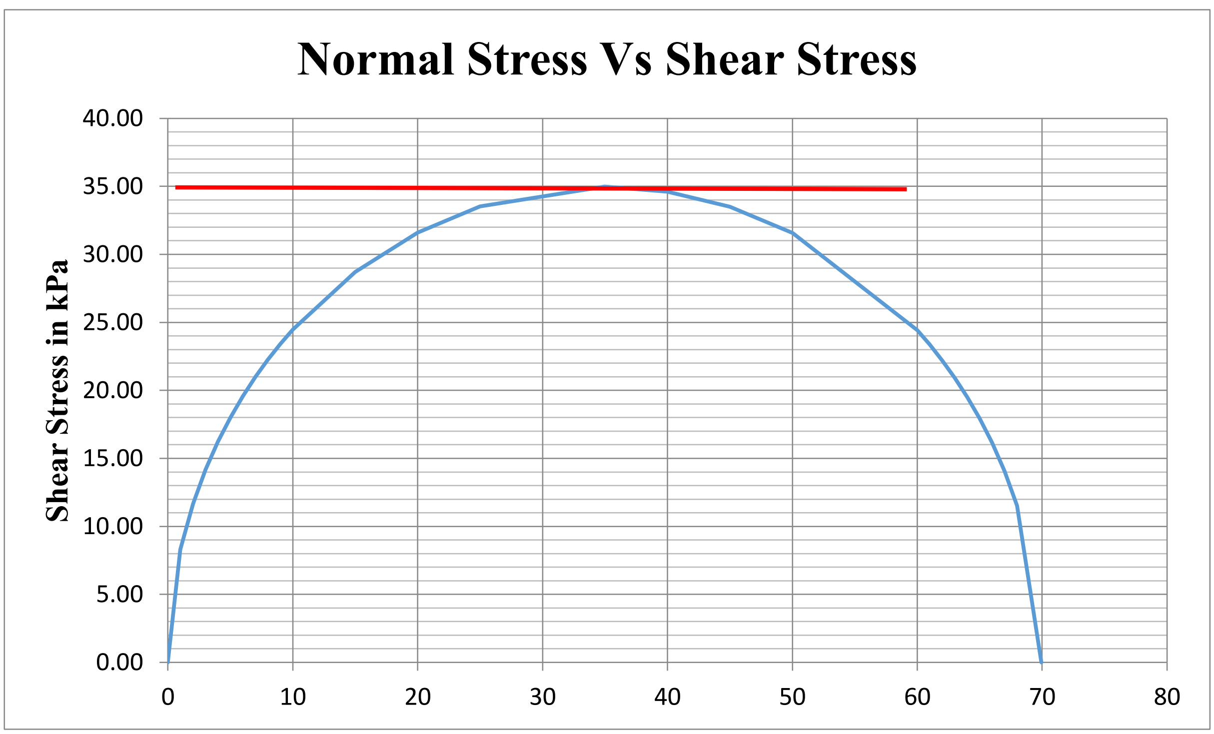


Fig B4. Mohr's circles for Unconfined compressive strength with strain rate of 0.4mm/min

Unconfined compressive strength, Qu	**72.90 kPa**
Undrained shear strength, su	**36.95 kPa**

Table B3: Unconfined compression strength test result for Asela kebele 09 with the strain rate of 1mm/min

Length(mm)	76		strain Rate (mm/min)		1.00
diameter (mm)	38		sample number		#1
Area(m2)	0.001134115		sample type		Remolded
project area	kebele 09		Depth		3.00m
Def.mm	Strain (%)	R3=1-strain	Load in N	corrected area=Ao/R3	Stress (kpa)=P/Ac
0	0	1	2	0.001134115	1.763489674
0.024	0.03157895	0.999684211	8	0.001134473	7.051731131
0.12	0.15789474	0.998421053	31	0.001135908	27.29093086
0.51	0.67105263	0.993289474	39	0.001141777	34.15728674
1.002	1.31842105	0.986815789	46	0.001149267	40.02550747
1.5	1.97368421	0.980263158	61	0.001156949	52.72486069
2.004	2.63684211	0.973631579	71	0.00116483	60.95311787
2.4	3.15789474	0.968421053	76	0.001171097	64.89642001
3.048	4.01052632	0.959894737	81	0.001181499	68.5569605
3.51	4.61842105	0.953815789	83	0.001189029	69.80483827
3.99	5.25	0.9475	87	0.001196955	72.68443128
4.5	5.92105263	0.940789474	87	0.001205493	72.16965472
5.004	6.58421053	0.934157895	90	0.001214051	74.13200106
7.002	9.21315789	0.907868421	93	0.001249206	74.44727125
7.5	9.86842105	0.901315789	93	0.001258288	73.90994059
8.502	11.1868421	0.888131579	92	0.001276967	72.04569996
9.504	12.5052632	0.874947368	92	0.001296209	70.97618988
10.5	13.8157895	0.861842105	87	0.00131592	66.11345992
11.01	14.4868421	0.855131579	85	0.001326246	64.09066765
11.496	15.1263158	0.848736842	81	0.001336239	60.61791561
12	15.7894737	0.842105263	78	0.001346762	57.91671351
12.51	16.4605263	0.835394737	73	0.00135758	53.77216472
12.996	17.1	0.829	68	0.001368052	49.70571996
13.5	17.7631579	0.822368421	64	0.001379084	46.407623
14.004	18.4263158	0.815736842	61	0.001390295	43.87557669
14.49	19.0657895	0.809342105	59	0.00140128	42.10436014
15	19.7368421	0.802631579	58	0.001412996	41.04754255
15.504	20.4	0.796	56	0.001424768	39.30465786
16.5	21.7105263	0.782894737	54	0.001448617	37.27692318
17.01	22.3815789	0.776184211	53	0.001461141	36.27301027
17.49	23.0131579	0.769868421	51	0.001473128	34.62020278
18	23.6842105	0.763157895	49	0.001486082	32.97261614
18.192	23.9368421	0.760631579	47	0.001491017	31.52209948

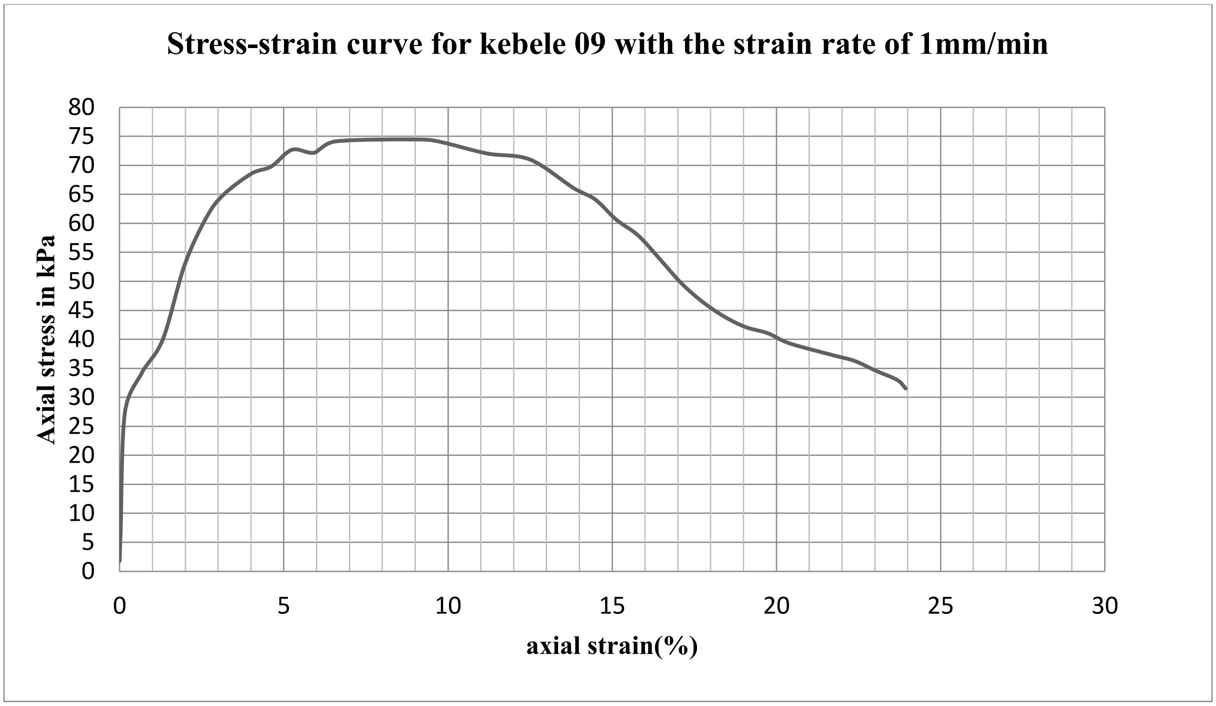


Fig.B5 stress –strain curve for strain rate of 1mm/min for kebele 09

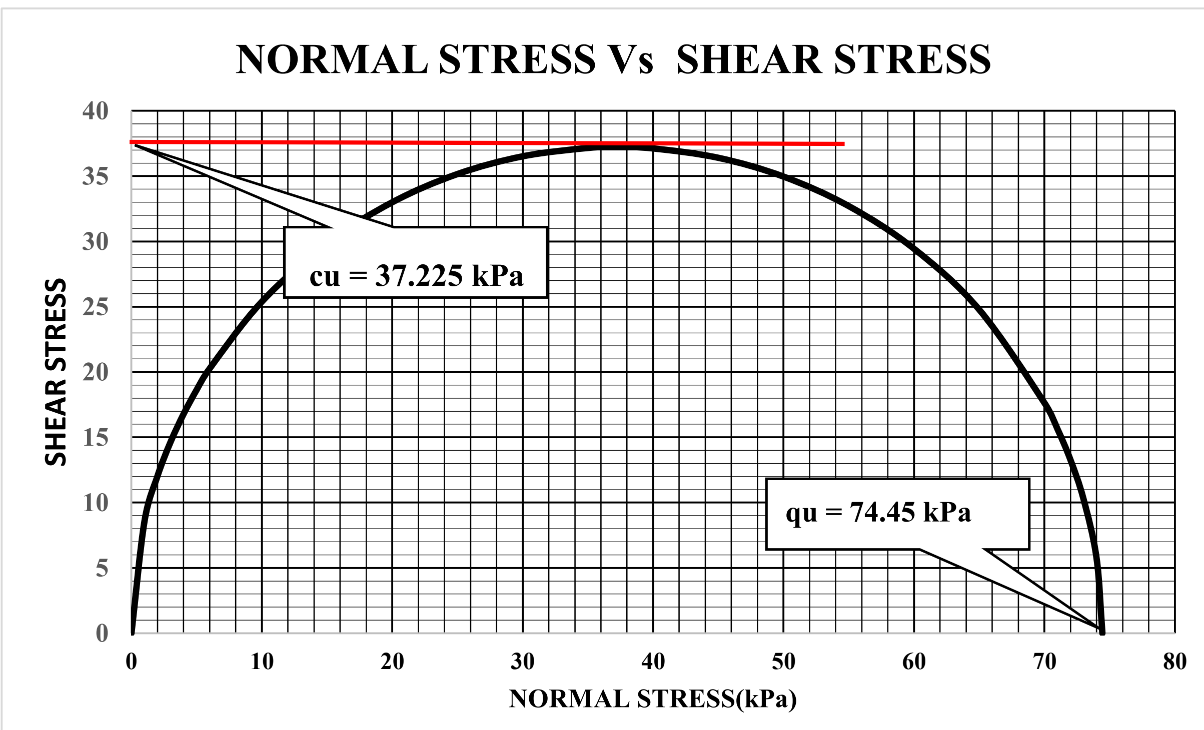


Fig.B6.Mohr's circles for Unconfined compressive strength with strain rate 1mm/min

Unconfined compressive strength, qu	**74.45 kPa**
Undrained shear strength, su	**37.225 kPa**

Table B4: Unconfined compression strength test for Asela kebele 08 with the strain rate of 1.52mm/min

Length (mm)	76		strain Rate (mm/min)	1.52
diameter (mm)	38		sample number	#1
Area(m2)	0.001134115		sample type	Remolded
project area	Asela kebele 08		Depth	3.00m
Deformation	Strain (%)	load (N)	Ac=Ao/(1-e)	Stress(kPa)
0	0	0	0.001134115	0
0.106	0.139473684	2	0.001135699	1.76103007
0.387	0.509210526	2	0.00113992	1.754509799
0.781	1.027631579	2	0.00114589	1.745367497
0.903	1.188157895	2	0.001147752	1.742536632
2.277	2.996052632	61	0.001169143	52.17496516
2.457	3.232894737	70	0.001172005	59.72672683
2.652	3.489473684	78	0.00117512	66.37617348
2.804	3.689473684	85	0.001177561	72.18311293
3.002	3.95	90	0.001180755	76.22243244
3.166	4.165789474	93	0.001183413	78.58622792
3.257	4.285526316	95	0.001184894	80.17595585
3.416	4.494736842	97	0.001187489	81.68493452
3.801	5.001315789	98	0.001193822	82.08930734
3.999	5.261842105	100	0.001197105	83.5348816
4.021	5.290789474	100	0.001197471	83.5093574
4.127	5.430263158	100	0.001199237	83.3863772
4.258	5.602631579	98	0.001201426	81.56970439
4.345	5.717105263	97	0.001202885	80.63945199
4.432	5.831578947	93	0.001204347	77.22024274
4.511	5.935526316	92	0.001205678	76.3055949
4.694	6.176315789	88	0.001208773	72.80112325
4.852	6.384210526	87	0.001211457	71.81435796
4.94	6.5	85	0.001212957	70.07667093
5.003	6.582894737	85	0.001214033	70.01454272
5.09	6.697368421	83	0.001215523	68.28336435
5.2	6.842105263	83	0.001217412	68.17743896
5.301	6.975	83	0.001219151	68.08018018
5.402	7.107894737	83	0.001220895	67.9829214
5.462	7.186842105	81	0.001221933	66.28839346
5.6	7.368421053	81	0.001224329	66.15870735
5.85	7.697368421	81	0.001228692	65.92376876
6.28	8.263157895	80	0.00123627	64.71078952
6.503	8.556578947	80	0.001240237	64.50381152
6.6	8.684210526	80	0.00124197	64.41378073

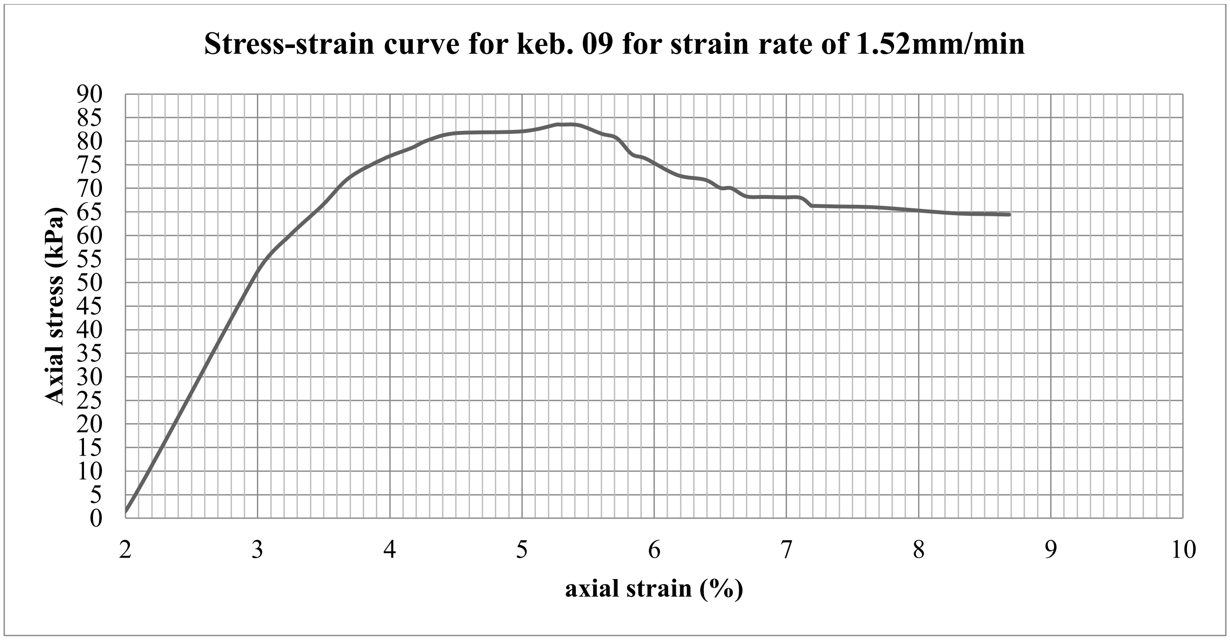


Fig B7. Stress-strain curve for strain rate of 1.52mm/min for kebele 09

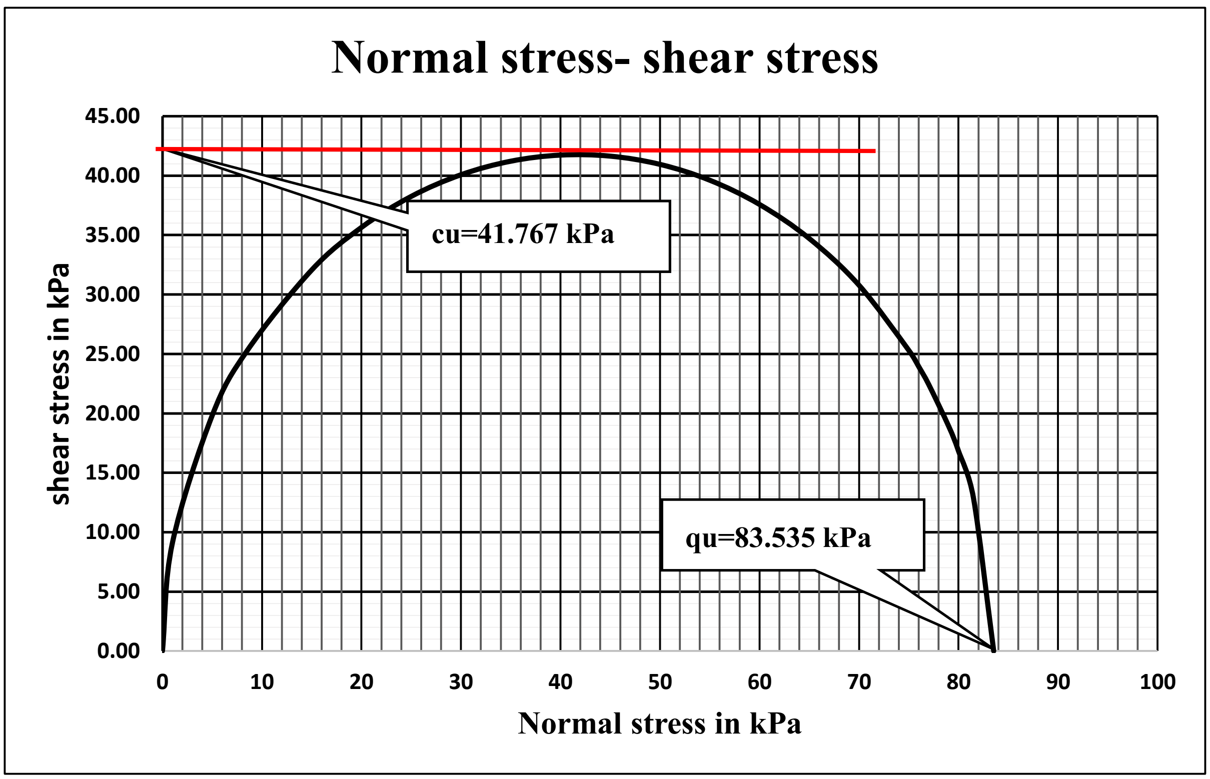


Fig B8. Mohr's circles for Unconfined compression test

Unconfined compressive strength, qu	83.535 kPa
Undrained shear strength, su	41.767 kPa

Table B5: Unconfined compression strength test for Asela kebele 09 with the strain rate of 2mm/min

Length(mm)	76			strain Rate (mm/min)	2
Diameter(mm)	38			sample number	#1
Area(m2)	0.001134115			sample type	Remolded
project area	kebele 09			Depth	3.00m
Deformation(mm)	Strain (%)	R3=1-strain	Load(N)	Ac=Ao/R3(m2)	stress (kPa)
0	0.000	1.000	0	0.001134115	0
0.076	0.100	0.999	10	0.00113525	8.80863
0.38	0.500	0.995	30	0.001139814	26.32021
0.76	1.000	0.990	40	0.001145571	34.917094
1.52	2.000	0.980	60	0.00115726	51.846590
2.28	3.000	0.970	80	0.001169191	68.423396
2.69	3.539	0.965	85	0.00117573	72.295510
3.04	4.000	0.960	88	0.00118137	74.489120
3.51	4.618	0.954	89	0.001189029	74.852110
3.8	5.000	0.950	90	0.001193805	75.389180
4.56	6.000	0.940	94	0.001206505	77.910971
5.25	6.908	0.931	95	0.001218272	77.979305
5.66	7.447	0.926	98	0.001225373	79.975645
6.08	8.000	0.920	100	0.001232734	81.120520
7.00	9.211	0.908	102	0.00124917	81.654209
7.6	10.000	0.900	105	0.001260128	83.324884
8.02	10.553	0.894	107	0.001267913	84.390635
9.12	12.000	0.880	109	0.001288767	84.576960
10.64	14.000	0.860	112	0.001318738	84.929659
11.86	15.605	0.844	113	0.001343822	84.088521
12.16	16.000	0.840	113	0.001350137	83.6952162
13.0	17.105	0.829	114	0.001368139	83.3248833
13.68	18.000	0.820	115	0.001383067	83.1485343
14.0	18.421	0.816	113	0.001390205	81.2829480
14.5	19.079	0.809	111	0.001401508	79.2004060
15.2	20.000	0.800	110	0.001417644	77.5935421
16.3	21.447	0.786	98	0.001443764	67.8781067

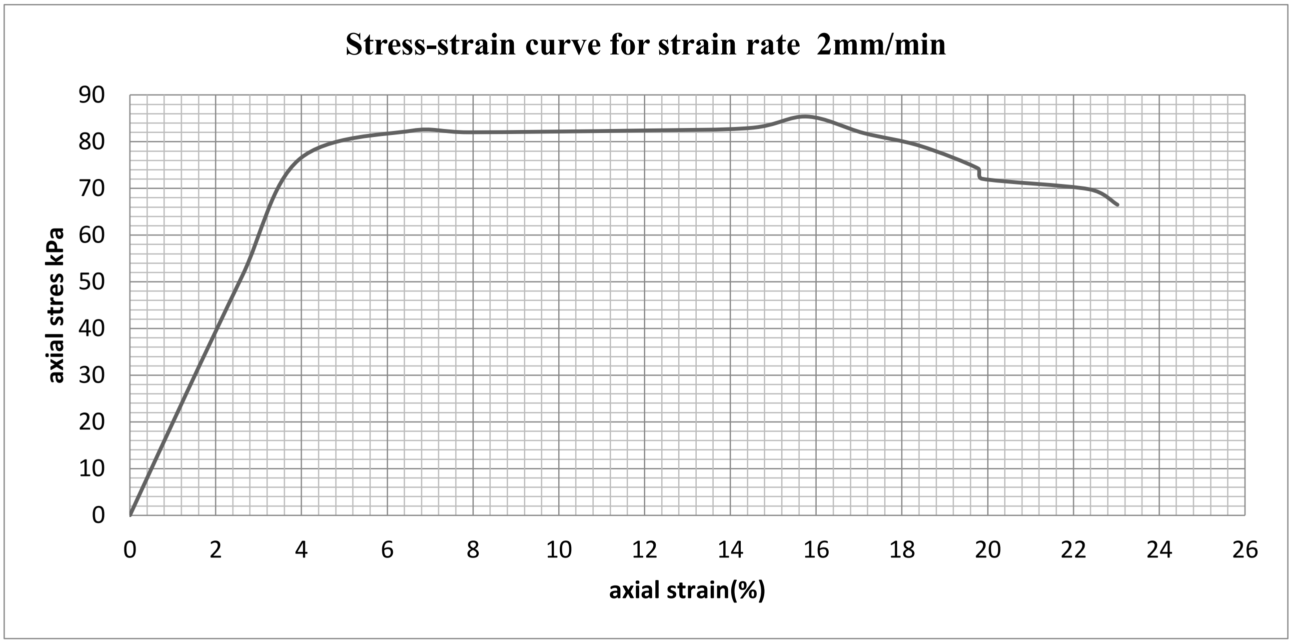


Fig B9. Stress- strain curve for strain rate of 2mm/min for keb.09

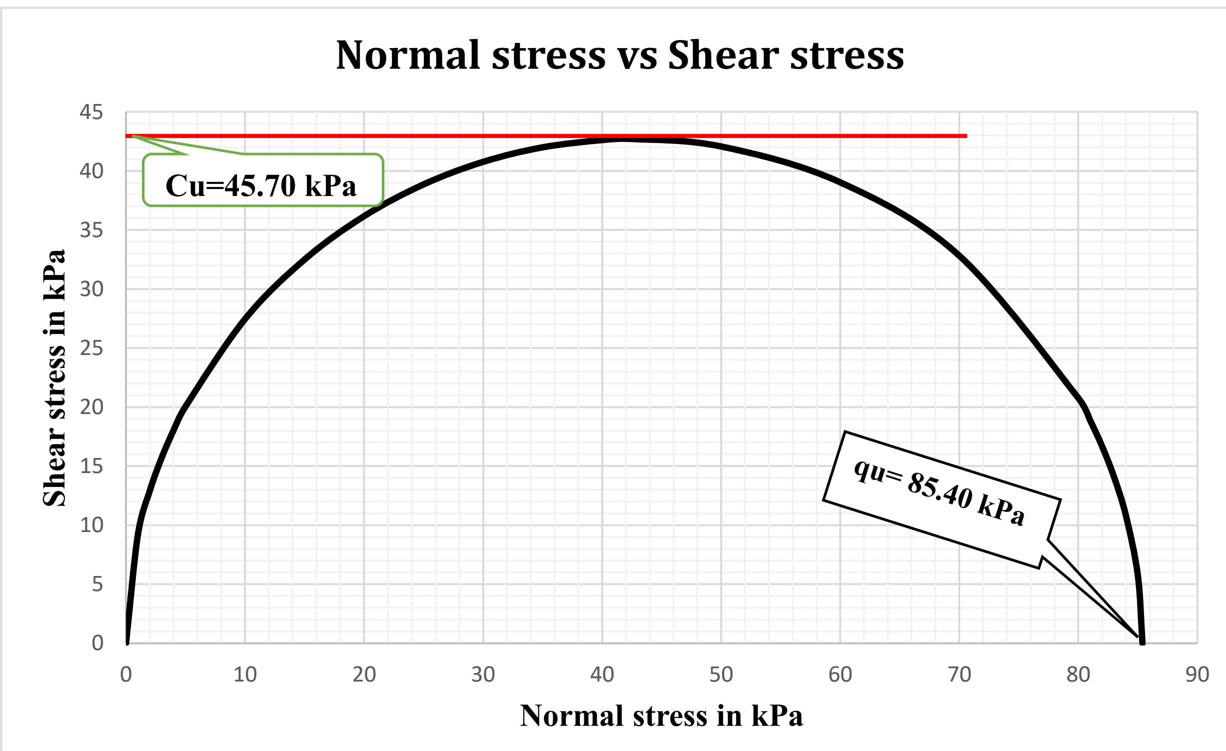


Fig. B10.Mohr's circles for unconfined compression strength for the strain rate of 2mm/min

Unconfined compression strength, qu	**85.39 kPa**
Undrained shear strength, cu	**42.695 kPa**

Table B6: Unconfined compression strength test for Asela kebele 08 with the strain rate of 5mm/min

Length(mm)	76		strain Rate (mm/min)		5.00
diameter (mm)	38		sample number		#1
Area(m2)	0.001134115		sample type		Remolded
project area	kebele 08		Depth		3.00m
Def.mm	Strain (%)	R3=1-strain (%)	Load in N	corrected area=Ao/R3	Stress kPa P/Ac
0	0.00000	1.00000	0	0.001134115	0.000
0.25	0.32895	0.99671	11	0.001137858	9.667
0.3	0.39474	0.99605	32	0.001138609	28.104
0.378	0.49737	0.99503	64	0.001139784	56.151
0.684	0.90000	0.99100	76	0.001144415	66.409
1.334	1.75526	0.98245	98	0.001154377	84.894
1.414	1.86053	0.98139	100	0.001155615	86.534
1.828	2.40526	0.97595	105	0.001162066	90.356
2.624	3.45263	0.96547	109	0.001174672	92.792
3.012	3.96316	0.96037	112	0.001180917	94.842
3.771	4.96184	0.95038	114	0.001193326	95.531
3.983	5.24079	0.94759	114	0.001196839	95.251
4.006	5.27105	0.94729	112	0.001197221	93.550
4.698	6.18158	0.93818	114	0.00120884	94.305
4.777	6.28553	0.93714	114	0.001210181	94.201
4.857	6.39079	0.93609	114	0.001211542	94.095
5.003	6.58289	0.93417	112	0.001214033	92.254
6.033	7.93816	0.92062	109	0.001231906	88.481
7.071	9.30395	0.90696	103	0.001250457	82.370
8.102	10.66053	0.89339	95	0.001269444	74.836
9.098	11.97105	0.88029	90	0.001288343	69.857
9.897	13.02237	0.86978	81	0.001303916	62.121
10.25	13.48684	0.86513	78	0.001310916	59.500
10.75	14.14474	0.85855	73	0.001320961	55.263
11.235	14.78289	0.85217	66	0.001330854	49.592
11.75	15.46053	0.84539	59.6	0.001341521	44.427
12.02	15.81579	0.84184	53	0.001347182	39.341
13	17.10526	0.82895	50	0.001368139	36.546
14.342	18.87105	0.81129	47	0.001397917	33.621
15.25	20.06579	0.79934	46	0.00141881	32.422

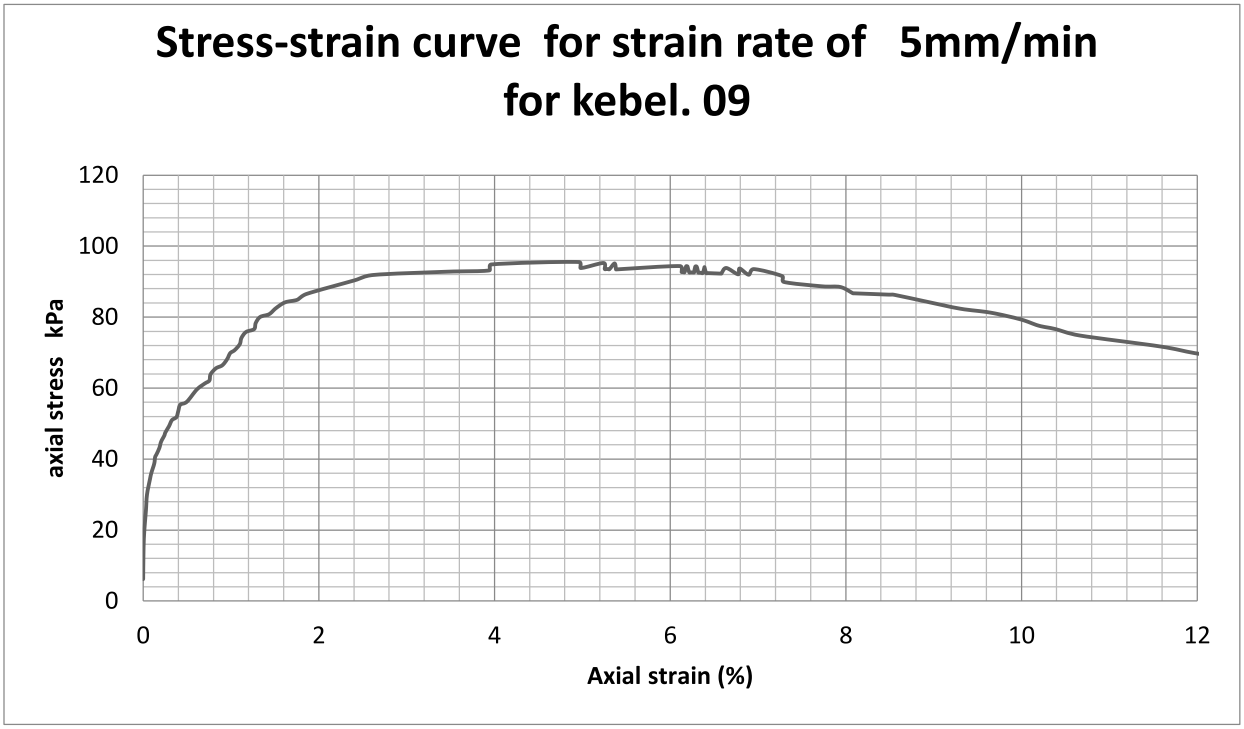


Fig B11. Stress-strain curve for strain rate of 5mm/min for keb. 09(remolded sample)

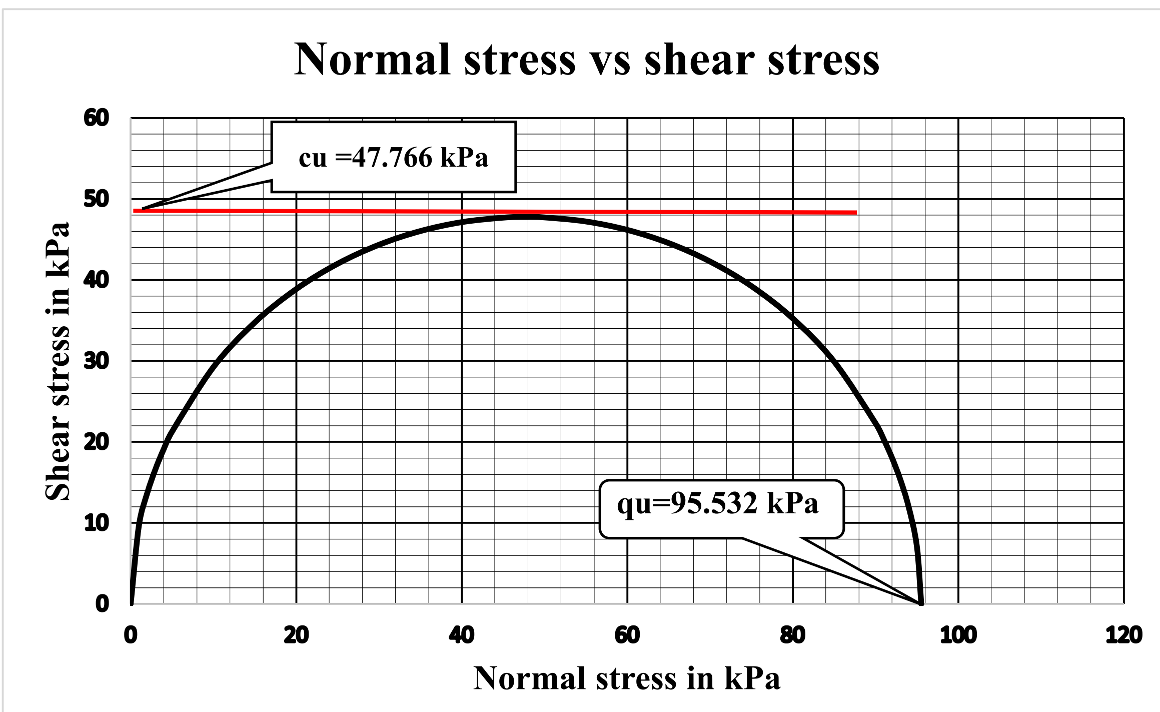


Fig B12. Mohr's circles for Unconfined compression strength with the rate of 5mm/min

Unconfined compression strength, qu	95.532 kPa
Undrained shear strength, cu	47.766 kPa

Table B7: Unconfined compression strength test result for Asela kebele 09 with the strain rate of 10mm/min

Length(mm)	76		strain Rate (mm/min)		10.00
Diameter (mm)	38		sample number		#1
Area(m2)	0.001134115		sample type		Remolded
project area	kebele 08		Depth		3.00m
Def.mm	Strain (%)	R3=1-strain	Load in N	corrected area=Ao/R3	stress (kPa) P/Ac
0.0000	0.000000	1.000000	2	0.0011341	1.763
0.0010	0.001316	0.999987	8	0.0011341	7.054
0.0100	0.013158	0.999868	17	0.0011343	14.988
0.2500	0.328947	0.996711	46	0.0011379	40.427
0.4000	0.526316	0.994737	70	0.0011401	61.397
0.8300	1.092105	0.989079	87	0.0011466	75.874
1.0010	1.317105	0.986829	95	0.0011493	82.662
1.3900	1.828947	0.981711	100	0.0011552	86.562
2.1010	2.764474	0.972355	105	0.0011664	90.024
2.5070	3.298684	0.967013	107	0.0011728	91.234
2.7705	3.645395	0.963546	109	0.0011770	92.607
3.1310	4.119737	0.958803	112	0.0011828	94.687
3.4685	4.563816	0.954362	114	0.0011883	95.931
3.7945	4.992763	0.950072	115	0.0011937	96.338
4.6010	6.053947	0.939461	117	0.0012072	96.919
4.6130	6.069737	0.939303	115	0.0012074	95.246
5.0100	6.592105	0.934079	112	0.0012142	92.245
5.2710	6.935526	0.930645	88	0.0012186	72.212
5.5000	7.236842	0.927632	84	0.0012226	68.706
6.1510	8.093421	0.919066	84	0.0012340	68.072
7.0210	9.238158	0.907618	78	0.0012496	62.422
8.6000	11.315789	0.886842	70	0.0012788	54.738
9.0000	11.842105	0.881579	66	0.0012865	51.304
10.0010	13.159211	0.868408	64	0.0013060	49.006
10.5000	13.815789	0.861842	58	0.0013159	44.076
11.0000	14.473684	0.855263	56	0.0013260	42.231
12.5000	16.447368	0.835526	55	0.0013574	40.520
13.0000	17.105263	0.828947	54	0.0013681	39.470
14.0000	18.421053	0.815789	53	0.0013902	38.124

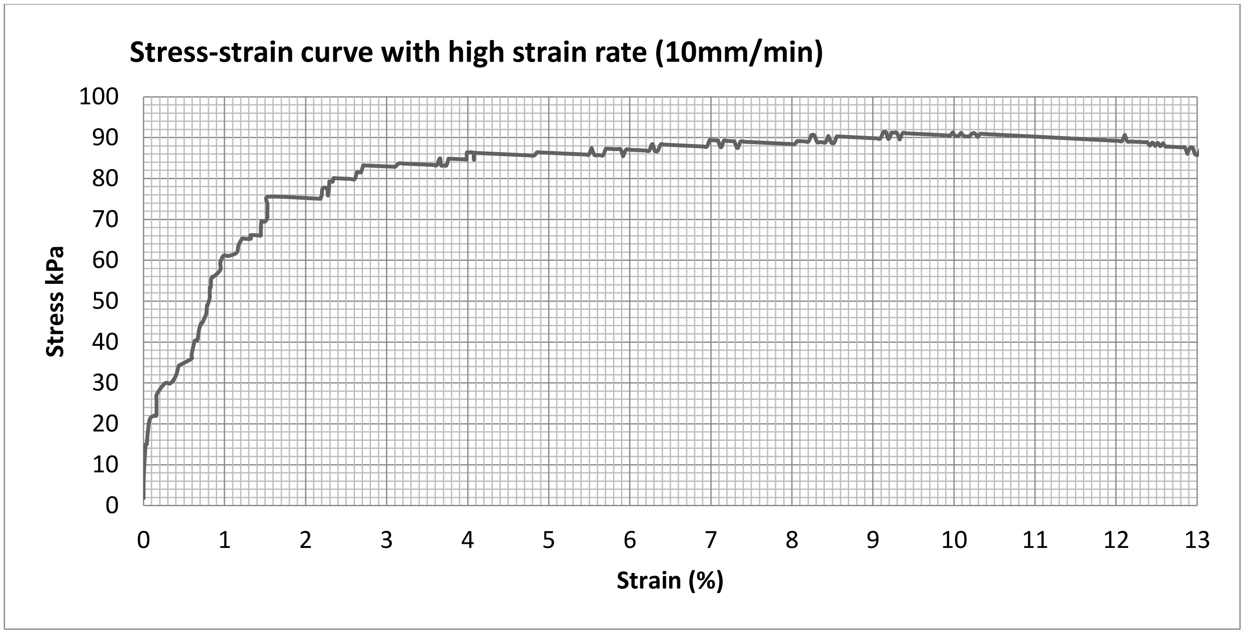


Fig B13. Stress- strain curve for strain rate of 10mm/min for kebele 09 (remolded soil)

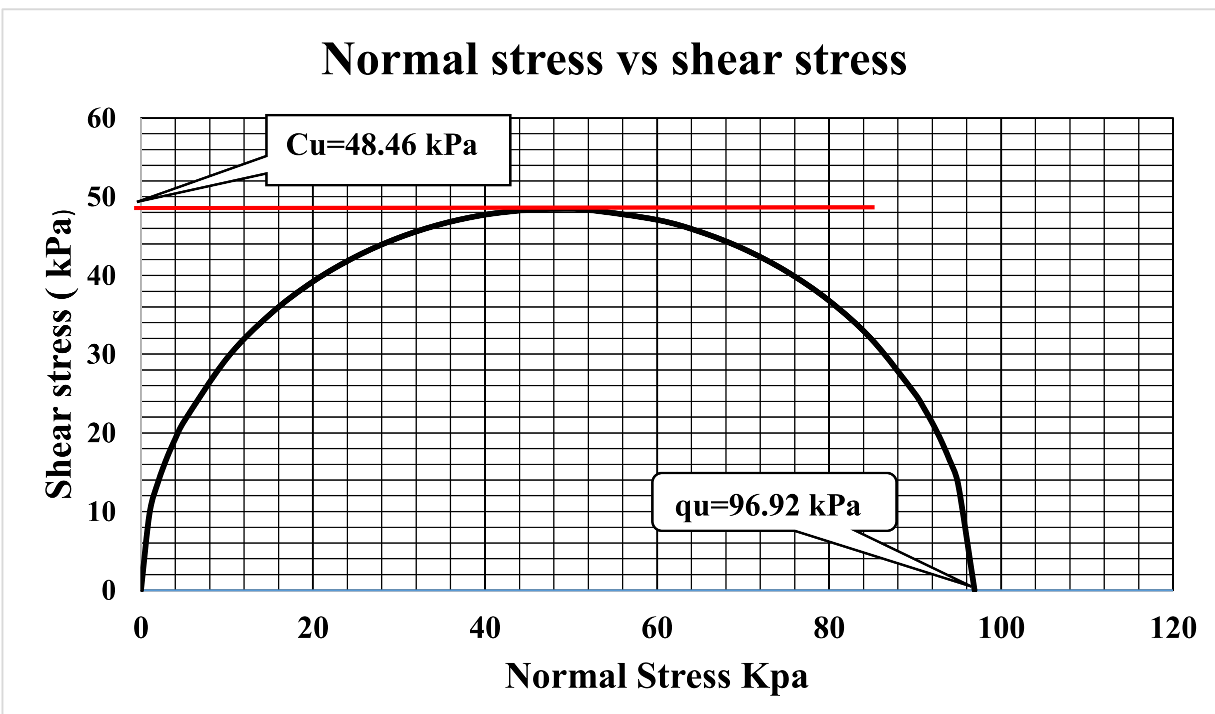


Fig B14. Mohr's Circle for Unconfined compression test

Unconfined compression strength, qu	**96.92 kPa**
Undrained shear strength, Su	**48.46 kPa**

APPENDIX C

1) TRIAXIAL COMPRESSION TEST RESULT

1.1) Triaxial compression test result for strain rate 0.001mm/min

Table C1: consolidation Stage result for effective consolidation pressure of 200kPa, 300kPa and 400kPa

Location: Asela kebele 09 (chigign mefelfeya)						Job reference		Thesis research
Soil Description: Red brown Clay						pit No		#1
Test Method: CU with pore water pressure measurement, BS 1377,clause 8						sample No		#1
						Depth		2.8m
Remolded soil								
Effective consolidation pressure of 200 kPa			Effective consolidation pressure of 300 kPa			Effective consolidation pressure of 400 kPa		
Initial condition	CP,Kpa	500	Initial condition	CP,Kpa	650	Initial condition	CP,Kpa	750
	BP,Kpa	300		BP,Kpa	350		BP,Kpa	350
	PP,Kpa	489		PP,Kpa	593.43		PP,Kpa	715.5
Final condition	PP,Kpa	296.32	Final condition	PP,Kpa	301.6	Final condition	PP,Kpa	371.39
	Δvolum	3.03		Δvolum	5.46		Δvolume	5.25
	%consolidation	99.6		%consolidation	96		%consolidation	99.9
Sqrt of time	Δvolume,mm	PP,kPa	Sqrt of time	Δvolume, mm	PP,kPa	Sqrt of time	Δvolume, mm	PP,kPa
0.300	-0.420	489.146	0.000	-0.140	593.434	0.290	-0.770	715.50
0.370	-0.520	487.812	0.370	-0.240	594.198	0.360	-0.750	715.33
0.460	-0.660	304.888	0.460	-0.540	303.845	0.440	-1.080	350.06
0.560	-0.700	305.256	0.560	-0.740	303.204	0.540	-1.160	349.24
0.690	-0.780	305.348	0.500	-0.840	303.147	0.660	-1.190	349.07
0.840	-0.785	295.044	0.840	-0.940	303.156	0.810	-1.260	348.53
1.030	-0.791	295.044	1.030	-1.150	302.572	1.000	-1.370	348.08
1.260	-0.840	295.228	1.260	-1.220	302.393	1.220	-1.490	347.98
1.540	-0.874	295.32	1.540	-1.310	302.204	1.490	-1.570	347.81
1.890	-0.951	295.412	1.890	-1.490	302.298	1.830	-1.650	347.71
2.320	-1.021	295.504	2.320	-1.540	302.261	2.240	-1.780	347.62
2.840	-1.047	295.596	2.840	-1.790	302.204	2.740	-1.890	347.62
3.470	-1.142	295.688	3.470	-1.930	302.298	3.360	-2.070	347.27
4.250	-1.308	295.596	4.250	-2.130	302.119	4.110	-2.260	347.83
5.210	-1.525	295.78	5.210	-2.400	302.204	5.040	-2.480	347.27
6.380	-1.653	295.688	7.500	-3.130	302.204	6.170	-2.730	347.44
7.820	-1.889	295.688	8.800	-3.540	302.025	7.560	-3.060	347.44
9.570	-2.300	295.596	10.250	-4.001	302.298	9.260	-3.480	347.44
11.720	-2.530	295.412	11.720	-4.390	302.298	11.340	-3.930	347.54
14.360	-2.872	295.136	14.360	-4.960	302.478	13.890	-4.320	347.71
17.590	-3.219	295.228	17.590	-5.450	302.478	17.010	-4.680	347.81
21.540	-3.357	295.412	21.540	-5.550	302.478	20.830	-5.020	347.26
26.380	-3.452	295.78	26.380	-5.600	302.025	25.510	-5.160	346.98
32.310	-3.452	296.332	32.310	-5.600	301.582	31.250	-5.250	346.63

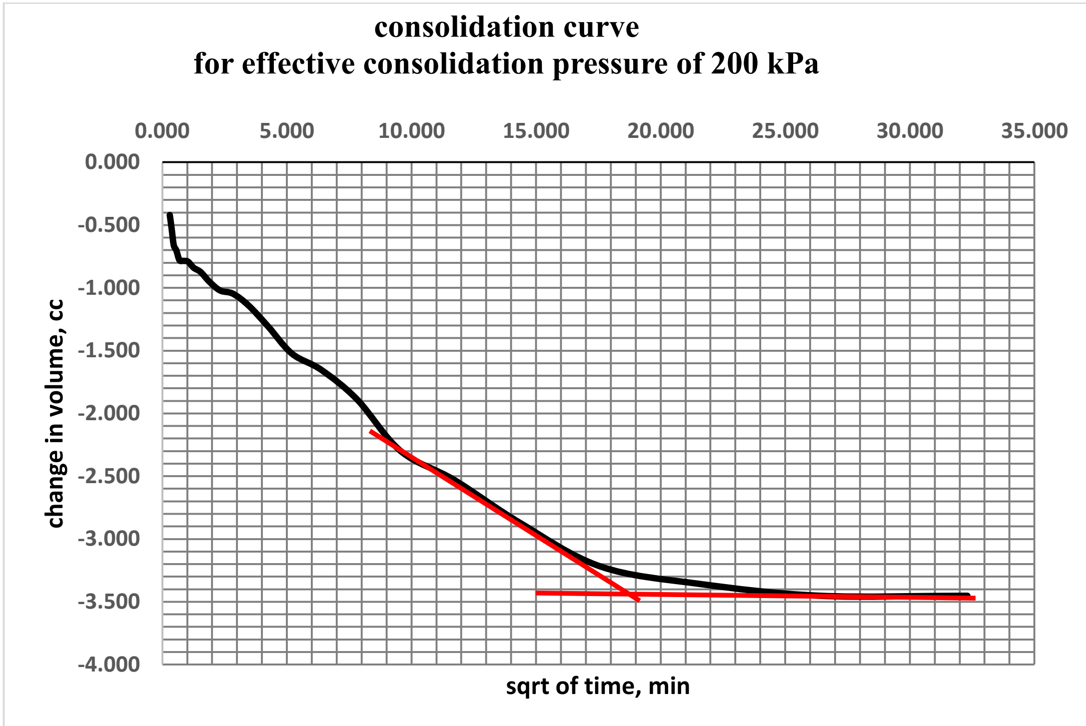


Fig C.1 consolidation curve for effective consolidation pressure of 200 kPa

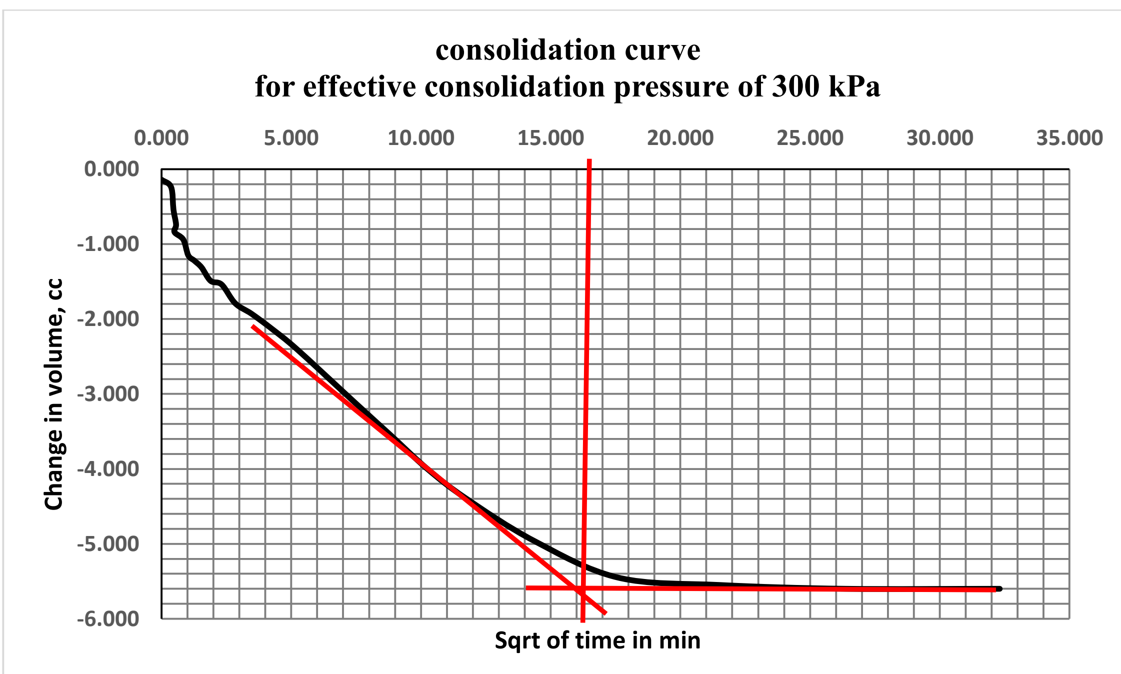


Fig C.2 consolidation curve for effective consolidation pressure of 300kPa

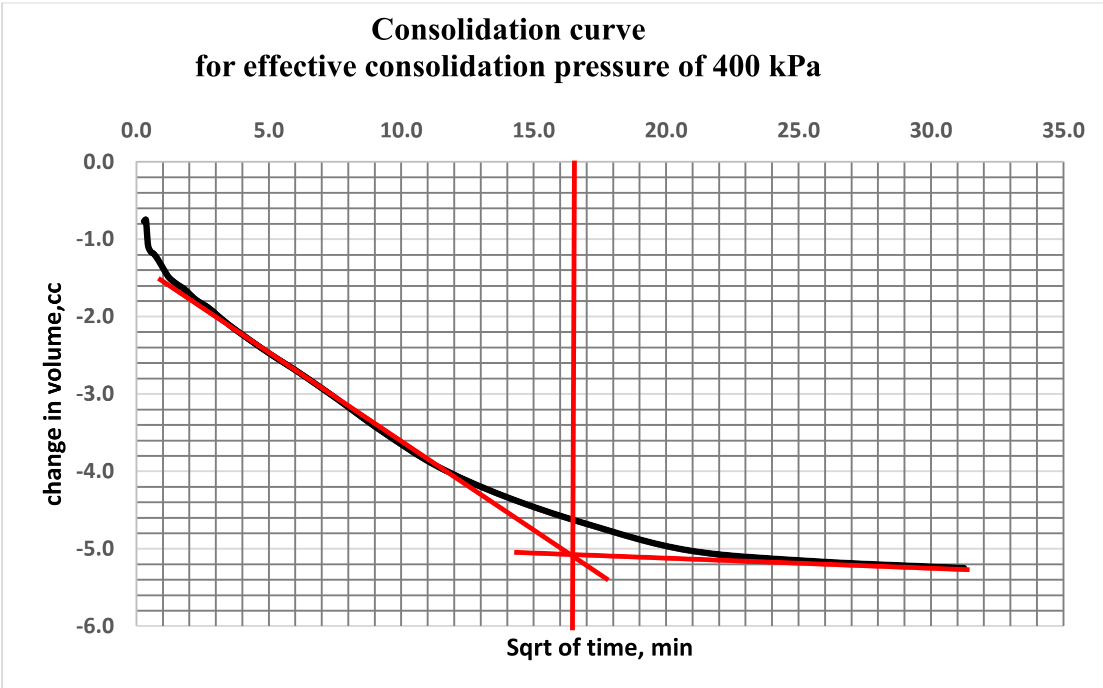


Fig C.3 consolidation curve for Effective consolidation pressure of 400 kPa

Table C2. Compression stage result for 200 kPa effective consolidation pressure													
Location			Asela kebele 09 (chigign mefelfeya area)					Job reference			thesis research		
Soil Description			Red brown clay					Pit number			1		
Test method			CU with measurement of pore water pressure; BS 1377: clause 8					Sample no			1		
								Depth			3.00m		
Area in mm2		1134	Strain rate		0.001mm/min			Effective stress (kPa)			200		
						Principle stresses						Stress path param	
Axial Disp. (mm)	Change in force (N)	Axial strain (%)	Area corrected (mm^2)	Change in Pore pr. (kPa)	Deviator stress (kPa)	Major (σ_1') (kPa)	major(σ1) (kPa)	minor (σ3) kPa	Minor (σ 3') (kPa)	σ_1'/σ_3' (-)'	Coefficient A (-)	s' (kPa)	T (kPa)
0.00	0.00	0.00	1134.11	0.00	0.00	200.00	200.00	200	200.00	1.00	-	200.00	0.00
0.60	56.99	0.79	1143.14	11.20	49.85	238.65	249.85	200	188.80	1.26	0.22	213.73	24.93
0.97	85.23	1.28	1148.78	18.02	74.19	256.17	274.19	200	181.98	1.41	0.24	219.08	37.10
1.20	103.32	1.58	1152.31	25.80	89.66	263.86	289.66	200	174.20	1.51	0.29	219.03	44.83
1.35	119.97	1.78	1154.62	33.22	103.90	270.68	303.90	200	166.78	1.62	0.32	218.73	51.95
1.55	136.26	2.04	1157.73	42.00	117.70	275.70	317.70	200	158.00	1.74	0.36	216.85	58.85
1.75	145.08	2.30	1160.84	46.31	124.98	278.67	324.98	200	153.69	1.81	0.37	216.18	62.49
1.95	157.68	2.57	1163.98	54.10	135.47	281.37	335.47	200	145.90	1.93	0.40	213.63	67.73
2.15	171.45	2.83	1167.13	58.61	146.90	288.29	346.90	200	141.39	2.04	0.40	214.84	73.45
2.55	191.79	3.36	1173.49	70.52	163.44	292.92	363.44	200	129.48	2.26	0.43	211.20	81.72
2.75	198.36	3.62	1176.69	75.88	168.57	292.69	368.57	200	124.12	2.36	0.45	208.41	84.29
2.98	203.58	3.92	1180.40	83.22	172.47	289.25	372.47	200	116.78	2.48	0.48	203.01	86.23
3.20	211.50	4.21	1183.97	90.14	178.64	288.50	378.64	200	109.86	2.63	0.50	199.18	89.32
3.40	216.72	4.47	1187.23	93.33	182.54	289.21	382.54	200	106.67	2.71	0.51	197.94	91.27
3.80	228.32	5.00	1193.81	99.10	191.25	292.15	391.25	200	100.90	2.90	0.52	196.53	95.63
4.00	232.65	5.26	1197.12	103.23	194.34	291.11	394.34	200	96.77	3.01	0.53	193.94	97.17
4.20	236.55	5.53	1200.46	105.53	197.05	291.52	397.05	200	94.47	3.09	0.54	192.99	98.52
4.40	239.52	5.79	1203.81	108.03	198.97	290.94	398.97	200	91.97	3.16	0.54	191.45	99.48
4.58	242.93	6.03	1206.84	108.89	201.29	292.40	401.29	200	91.11	3.21	0.54	191.76	100.65
4.79	248.29	6.30	1210.40	111.23	205.13	293.90	405.13	200	88.77	3.31	0.54	191.34	102.57
4.99	251.33	6.57	1213.81	114.73	207.05	292.32	407.05	200	85.27	3.43	0.55	188.80	103.53

5.19	254.88	6.83	1217.24	114.80	209.39	294.59	409.39	200	85.20	3.46	0.55	189.90	104.70
5.37	257.86	7.07	1220.34	114.93	211.30	296.37	411.30	200	85.07	3.48	0.54	190.72	105.65
5.56	260.94	7.32	1223.63	116.02	213.25	297.23	413.25	200	83.98	3.54	0.54	190.60	106.62
5.79	263.69	7.62	1227.64	116.00	214.79	298.79	414.79	200	84.00	3.56	0.54	191.40	107.40
5.97	265.79	7.86	1230.80	114.33	215.95	301.62	415.95	200	85.67	3.52	0.53	193.64	107.97
6.20	269.51	8.16	1234.85	114.37	218.26	303.89	418.26	200	85.63	3.55	0.52	194.76	109.13
6.41	272.24	8.43	1238.58	112.99	219.80	306.81	419.80	200	87.01	3.53	0.51	196.91	109.90
6.62	274.99	8.71	1242.33	111.66	221.35	309.69	421.35	200	88.34	3.51	0.50	199.01	110.67
6.83	275.85	8.99	1246.10	111.63	221.37	309.74	421.37	200	88.37	3.51	0.50	199.06	110.69
7.04	279.58	9.26	1249.89	111.02	223.68	312.66	423.68	200	88.98	3.51	0.50	200.82	111.84
7.24	281.84	9.53	1253.53	111.33	224.84	313.51	424.84	200	88.67	3.54	0.50	201.09	112.42
7.45	286.12	9.80	1257.37	110.52	227.55	317.03	427.55	200	89.48	3.54	0.49	203.26	113.78
7.66	286.04	10.08	1261.23	110.26	226.79	316.53	426.79	200	89.74	3.53	0.49	203.14	113.40
8.07	289.75	10.62	1268.85	108.66	228.35	319.69	428.35	200	91.34	3.50	0.48	205.52	114.18
8.27	292.56	10.88	1272.59	107.03	229.90	322.87	429.90	200	92.97	3.47	0.47	207.92	114.95
8.47	294.44	11.14	1276.36	106.99	230.69	323.70	430.69	200	93.01	3.48	0.46	208.36	115.35
8.67	295.80	11.41	1280.15	106.92	231.07	324.15	431.07	200	93.08	3.48	0.46	208.61	115.53
9.06	297.58	11.92	1287.61	106.20	231.11	324.91	431.11	200	93.80	3.46	0.46	209.35	115.55
9.27	301.51	12.20	1291.66	105.23	233.43	328.20	433.43	200	94.77	3.46	0.45	211.48	116.71
9.47	303.91	12.46	1295.55	105.23	234.58	329.35	434.58	200	94.77	3.48	0.45	212.06	117.29
9.67	305.33	12.72	1299.45	105.23	234.97	329.74	434.97	200	94.77	3.48	0.45	212.26	117.49
9.86	305.74	12.97	1303.19	106.37	234.61	328.24	434.61	200	93.63	3.51	0.45	210.93	117.30
10.04	307.58	13.21	1306.74	105.33	235.38	330.05	435.38	200	94.67	3.49	0.45	212.36	117.69
10.20	309.36	13.42	1309.92	106.37	236.16	329.79	436.16	200	93.63	3.52	0.45	211.71	118.08
10.38	309.73	13.66	1313.51	105.63	235.80	330.17	435.80	200	94.37	3.50	0.45	212.27	117.90
10.58	311.17	13.92	1317.53	105.23	236.17	330.94	436.17	200	94.77	3.49	0.45	212.86	118.09
10.80	313.79	14.21	1321.97	105.12	237.36	332.24	437.36	200	94.88	3.50	0.44	213.56	118.68
11.02	314.87	14.50	1326.45	104.99	237.37	332.38	437.37	200	95.01	3.50	0.44	213.70	118.69
11.23	316.40	14.78	1330.75	104.63	237.76	333.13	437.76	200	95.37	3.49	0.44	214.25	118.88
11.44	317.43	15.05	1335.08	103.23	237.76	334.53	437.76	200	96.77	3.46	0.43	215.65	118.88
11.60	316.67	15.26	1338.40	103.49	236.61	333.12	436.61	200	96.51	3.45	0.44	214.81	118.30
11.79	320.23	15.51	1342.36	103.00	238.56	335.56	438.56	200	97.00	3.46	0.43	216.28	119.28
11.96	320.04	15.74	1345.92	102.02	237.79	335.77	437.79	200	97.98	3.43	0.43	216.87	118.89
12.18	321.18	16.03	1350.56	101.63	237.81	336.18	437.81	200	98.37	3.42	0.43	217.28	118.91
12.40	322.82	16.32	1355.23	101.37	238.20	336.83	438.20	200	98.63	3.42	0.43	217.73	119.10

12.62	325.02	16.61	1359.94	101.36	238.99	337.63	438.99	200	98.64	3.42	0.42	218.14	119.50
12.85	324.64	16.91	1364.89	99.98	237.85	337.87	437.85	200	100.02	3.38	0.42	218.95	118.93
13.06	324.14	17.18	1369.44	99.63	236.70	337.07	436.70	200	100.37	3.36	0.42	218.72	118.35
13.24	328.26	17.42	1373.37	99.13	239.02	339.89	439.02	200	100.87	3.37	0.41	220.38	119.51
13.45	328.87	17.70	1377.98	98.99	238.66	339.67	438.66	200	101.01	3.36	0.41	220.34	119.33
13.67	330.02	17.99	1382.85	99.56	238.65	339.09	438.65	200	100.44	3.38	0.42	219.77	119.33
13.88	330.65	18.26	1387.52	99.65	238.30	338.65	438.30	200	100.35	3.37	0.42	219.50	119.15
14.09	332.32	18.54	1392.23	99.54	238.69	339.15	438.69	200	100.46	3.38	0.42	219.81	119.35
14.30	334.02	18.82	1396.96	99.15	239.10	339.95	439.10	200	100.85	3.37	0.41	220.40	119.55
14.51	334.07	19.09	1401.74	98.96	238.33	339.37	438.33	200	101.04	3.36	0.42	220.20	119.16
14.70	334.59	19.34	1406.08	99.15	237.96	338.81	437.96	200	100.85	3.36	0.42	219.83	118.98
14.89	337.26	19.59	1410.45	98.89	239.11	340.22	439.11	200	101.11	3.36	0.41	220.67	119.56
15.07	337.75	19.83	1414.62	99.65	238.76	339.11	438.76	200	100.35	3.38	0.42	219.73	119.38
15.27	336.16	20.09	1419.28	98.69	236.85	338.16	436.85	200	101.31	3.34	0.42	219.74	118.43
15.46	339.98	20.34	1423.73	99.21	238.80	339.59	438.80	200	100.79	3.37	0.42	220.19	119.40
15.87	341.78	20.88	1433.44	99.22	238.44	339.22	438.44	200	100.78	3.37	0.42	220.00	119.22
16.07	342.41	21.14	1438.22	99.23	238.07	338.84	438.07	200	100.77	3.36	0.42	219.81	119.04
16.28	345.06	21.42	1443.28	99.34	239.08	339.74	439.08	200	100.66	3.38	0.42	220.20	119.54
16.48	343.08	21.68	1448.13	99.35	236.91	337.56	436.91	200	100.65	3.35	0.42	219.11	118.46
16.68	345.69	21.95	1453.01	98.89	237.91	339.02	437.91	200	101.11	3.35	0.42	220.07	118.96
16.87	346.50	22.20	1457.68	98.96	237.71	338.75	437.71	200	101.04	3.35	0.42	219.89	118.85
17.09	347.82	22.49	1463.13	99.21	237.73	338.52	437.73	200	100.79	3.36	0.42	219.65	118.86
17.70	347.76	23.29	1478.43	98.89	235.22	336.33	435.22	200	101.11	3.33	0.42	218.72	117.61
17.91	350.46	23.57	1483.78	99.00	236.19	337.19	436.19	200	101.00	3.34	0.42	219.10	118.10
18.11	353.16	23.83	1488.91	99.00	237.19	338.19	437.19	200	101.00	3.35	0.42	219.60	118.60
18.31	353.88	24.09	1494.07	99.00	236.86	337.86	436.86	200	101.00	3.35	0.42	219.43	118.43
18.51	353.16	24.36	1499.26	98.96	235.56	336.60	435.56	200	101.04	3.33	0.42	218.82	117.78
18.72	351.18	24.63	1504.76	99.00	233.38	334.38	433.38	200	101.00	3.31	0.42	217.69	116.69
18.93	353.88	24.91	1510.30	98.66	234.31	335.65	434.31	200	101.34	3.31	0.42	218.50	117.16
19.13	354.60	25.17	1515.61	99.66	233.97	334.31	433.97	200	100.34	3.33	0.43	217.32	116.98
19.33	356.58	25.43	1520.96	99.89	234.44	334.55	434.44	200	100.11	3.34	0.43	217.33	117.22
19.74	350.46	25.97	1532.04	98.66	228.75	330.09	428.75	200	101.34	3.26	0.43	215.72	114.38
19.93	354.60	26.22	1537.23	98.89	230.67	331.78	430.67	200	101.11	3.28	0.43	216.45	115.34
20.13	351.18	26.49	1542.74	99.32	227.63	328.31	427.63	200	100.68	3.26	0.44	214.50	113.82

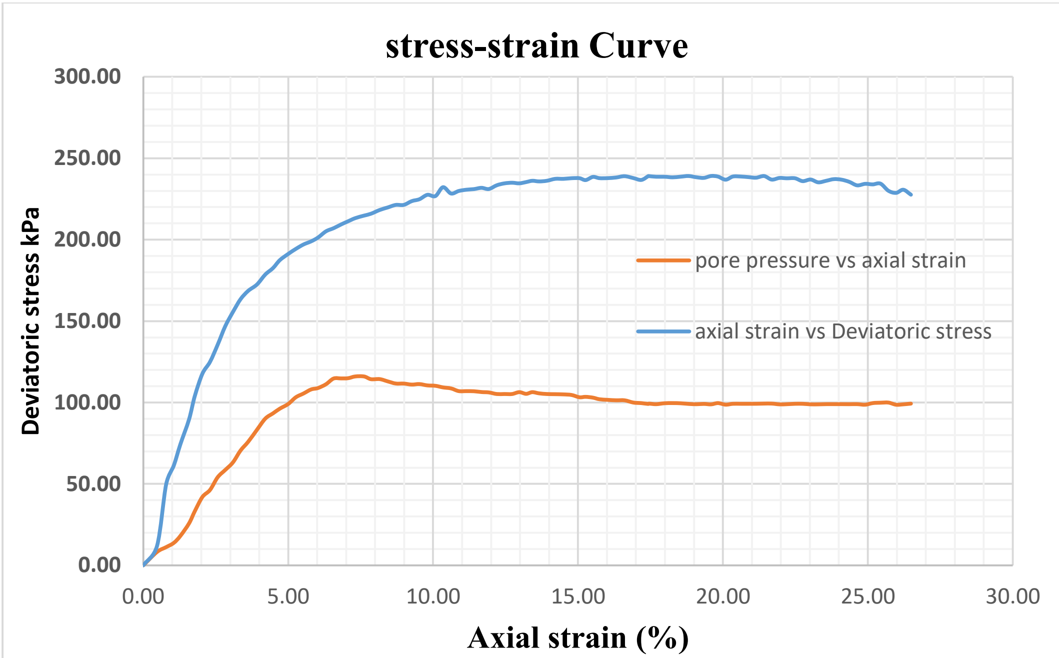


Fig C.4- Stress-strain Curve for effective consolidation pressure of 200 kPa and strain rate of 0.001mm/min

Table C3. Compression stage result for 300 kPa effective consolidation pressure													
Location			Asela kebele 09 (chigign mefelfeya area)					Job reference			thesis research		
soil Description			Red brown clay					Pit number			1		
Test method			CU with measurement of pore water pressure; BS 1377: clause 8					sample no			1		
								depth			3.00m		
Area in mm²		1134.	Strain rate in mm/min			0.001		Effective pressure			300		
Axial	Change in	Axial	Area	Change in	Deviator	Principle stresses					Coefficient	Stress path parameters	
Disp.	force	strain	corrected	pore pr.	stress	Major (σ₁')	major(σ1)	minor (σ3)	Minor (σ₃')	σ₁'/σ₃'	A	s'	t
(mm)	(N)	(%)	(mm²)	(kPa)	(kPa)	(kPa)	(kPa)	kPa	(kPa)	(-)'	(-)	(kPa)	(kPa)
0.00	0.00	0.00	1134.11	0.00	0.00	300.00	300.00	300	300.00	1.00	-	300.00	0.00
0.60	49.96	0.79	1143.14	2.30	43.70	341.40	343.70	300	297.70	1.15	0.05	319.55	21.85
0.97	70.66	1.28	1148.78	12.33	61.51	349.18	361.51	300	287.67	1.21	0.20	318.42	30.76
1.20	90.07	1.58	1152.31	33.83	78.17	344.33	378.17	300	266.17	1.29	0.43	305.25	39.08
1.35	105.21	1.78	1154.62	48.03	91.12	343.09	391.12	300	251.97	1.36	0.53	297.53	45.56
1.55	121.83	2.04	1157.73	61.42	105.23	343.81	405.23	300	238.58	1.44	0.58	291.19	52.62
1.75	136.22	2.30	1160.84	73.18	117.35	344.16	417.35	300	226.82	1.52	0.62	285.49	58.67
1.95	149.22	2.57	1163.98	86.17	128.20	342.03	428.20	300	213.83	1.60	0.67	277.93	64.10
2.15	162.96	2.83	1167.13	99.09	139.63	340.53	439.63	300	200.91	1.69	0.71	270.72	69.81
2.55	176.94	3.36	1173.49	108.99	150.78	341.79	450.78	300	191.01	1.79	0.72	266.40	75.39
2.75	194.91	3.62	1176.69	122.89	165.64	342.75	465.64	300	177.11	1.94	0.74	259.93	82.82
2.98	213.25	3.92	1180.40	133.63	180.66	347.02	480.66	300	166.37	2.09	0.74	256.70	90.33
3.20	226.76	4.21	1183.97	139.99	191.52	351.53	491.52	300	160.01	2.20	0.73	255.77	95.76
3.40	243.89	4.47	1187.23	146.17	205.43	359.25	505.43	300	153.83	2.34	0.71	256.54	102.71
3.80	257.68	5.00	1193.81	151.12	215.85	364.72	515.85	300	148.88	2.45	0.70	256.80	107.92
4.00	271.93	5.26	1197.12	154.52	227.16	372.63	527.16	300	145.48	2.56	0.68	259.05	113.58
4.20	282.75	5.53	1200.46	157.92	235.54	377.61	535.54	300	142.08	2.66	0.67	259.84	117.77
4.40	292.73	5.79	1203.81	161.32	243.17	381.85	543.17	300	138.68	2.75	0.66	260.26	121.59
4.58	299.28	6.03	1206.84	164.10	247.98	383.88	547.98	300	135.90	2.82	0.66	259.89	123.99
4.79	305.73	6.30	1210.40	166.89	252.59	385.69	552.59	300	133.11	2.90	0.66	259.40	126.29
4.99	310.89	6.57	1213.81	168.74	256.12	387.38	556.12	300	131.26	2.95	0.66	259.32	128.06
5.19	315.85	6.83	1217.24	169.67	259.48	389.81	559.48	300	130.33	2.99	0.65	260.07	129.74

5.37	319.86	7.07	1220.34	170.29	262.10	391.81	562.10	300	129.71	3.02	0.65	260.76	131.05
5.56	323.93	7.32	1223.63	170.38	264.73	394.35	564.73	300	129.62	3.04	0.64	261.98	132.36
5.79	326.86	7.62	1227.64	170.60	266.25	395.64	566.25	300	129.40	3.06	0.64	262.52	133.12
5.97	330.15	7.86	1230.80	170.29	268.24	397.95	568.24	300	129.71	3.07	0.63	263.83	134.12
6.20	335.49	8.16	1234.85	170.29	271.69	401.39	571.69	300	129.71	3.09	0.63	265.55	135.84
6.41	337.58	8.43	1238.58	169.05	272.56	403.50	572.56	300	130.95	3.08	0.62	267.22	136.28
6.62	340.14	8.71	1242.33	168.12	273.79	405.67	573.79	300	131.88	3.08	0.61	268.77	136.89
6.83	344.83	8.99	1246.10	167.51	276.72	409.21	576.72	300	132.49	3.09	0.61	270.85	138.36
7.04	346.73	9.26	1249.89	166.89	277.41	410.51	577.41	300	133.11	3.08	0.60	271.81	138.70
7.24	349.14	9.53	1253.53	166.58	278.53	411.94	578.53	300	133.42	3.09	0.60	272.68	139.26
7.45	348.86	9.80	1257.37	165.65	277.46	411.80	577.46	300	134.35	3.07	0.60	273.07	138.73
7.66	351.00	10.08	1261.23	165.96	278.30	412.34	578.30	300	134.04	3.08	0.60	273.19	139.15
8.07	350.35	10.62	1268.85	165.03	276.12	411.08	576.12	300	134.97	3.05	0.60	273.03	138.06
8.27	354.53	10.88	1272.59	164.41	278.59	414.17	578.59	300	135.59	3.05	0.59	274.88	139.29
8.47	357.31	11.14	1276.36	163.18	279.95	416.76	579.95	300	136.82	3.05	0.58	276.79	139.97
8.67	362.24	11.41	1280.15	162.87	282.96	420.09	582.96	300	137.13	3.06	0.58	278.61	141.48
9.06	365.76	11.92	1287.61	162.56	284.06	421.50	584.06	300	137.44	3.07	0.57	279.47	142.03
9.27	373.47	12.20	1291.66	161.32	289.14	427.82	589.14	300	138.68	3.08	0.56	283.25	144.57
9.47	371.43	12.46	1295.55	161.01	286.70	425.68	586.70	300	138.99	3.06	0.56	282.34	143.35
9.67	372.82	12.72	1299.45	159.47	286.91	427.43	586.91	300	140.53	3.04	0.56	283.98	143.45
9.86	377.74	12.97	1303.19	159.00	289.86	430.86	589.86	300	141.00	3.06	0.55	285.93	144.93
10.04	379.14	13.21	1306.74	158.85	290.14	431.29	590.14	300	141.15	3.06	0.55	286.22	145.07
10.20	380.53	13.42	1309.92	157.92	290.50	432.57	590.50	300	142.08	3.04	0.54	287.33	145.25
10.38	383.31	13.66	1313.51	158.54	291.82	433.28	591.82	300	141.46	3.06	0.54	287.37	145.91
10.58	386.84	13.92	1317.53	157.30	293.61	436.31	593.61	300	142.70	3.06	0.54	289.50	146.81
10.80	387.59	14.21	1321.97	156.68	293.19	436.50	593.19	300	143.32	3.05	0.53	289.91	146.59
11.02	388.24	14.50	1326.45	156.37	292.69	436.31	592.69	300	143.63	3.04	0.53	289.97	146.34
11.23	391.02	14.78	1330.75	157.30	293.84	436.53	593.84	300	142.70	3.06	0.54	289.61	146.92
11.44	392.51	15.05	1335.08	156.37	294.00	437.62	594.00	300	143.63	3.05	0.53	290.62	147.00
11.60	395.94	15.26	1338.40	161.21	295.83	434.62	595.83	300	138.79	3.13	0.54	286.70	147.92
11.79	397.43	15.51	1342.36	154.52	296.07	441.54	596.07	300	145.48	3.04	0.52	293.51	148.03
11.96	406.71	15.74	1345.92	153.28	302.18	448.90	602.18	300	146.72	3.06	0.51	297.81	151.09
12.18	403.74	16.03	1350.56	152.35	298.94	446.59	598.94	300	147.65	3.02	0.51	297.12	149.47
12.40	402.26	16.32	1355.23	152.35	296.82	444.46	596.82	300	147.65	3.01	0.51	296.06	148.41

12.62	407.92	16.61	1359.94	151.43	299.96	448.52	599.96	300	148.57	3.02	0.50	298.55	149.98
12.85	410.06	16.91	1364.89	151.12	300.43	449.31	600.43	300	148.88	3.02	0.50	299.09	150.22
13.06	408.90	17.18	1369.44	152.05	298.59	446.53	598.59	300	147.95	3.02	0.51	297.24	149.29
13.24	412.30	17.42	1373.37	150.19	300.21	450.02	600.21	300	149.81	3.00	0.50	299.91	150.11
13.45	412.00	17.70	1377.98	151.12	298.99	447.86	598.99	300	148.88	3.01	0.51	298.37	149.49
13.67	417.47	17.99	1382.85	150.81	301.89	451.08	601.89	300	149.19	3.02	0.50	300.13	150.95
13.88	417.20	18.26	1387.52	148.21	300.68	452.47	600.68	300	151.79	2.98	0.49	302.13	150.34
14.09	420.69	18.54	1392.23	149.26	302.17	452.91	602.17	300	150.74	3.00	0.49	301.82	151.09
14.30	420.83	18.82	1396.96	147.41	301.24	453.83	601.24	300	152.59	2.97	0.49	303.21	150.62
14.51	423.87	19.09	1401.74	146.09	302.39	456.29	602.39	300	153.91	2.96	0.48	305.10	151.19
14.70	423.99	19.34	1406.08	144.50	301.54	457.03	601.54	300	155.50	2.94	0.48	306.27	150.77
14.89	426.19	19.59	1410.45	145.03	302.16	457.13	602.16	300	154.97	2.95	0.48	306.05	151.08
15.07	428.45	19.83	1414.62	144.23	302.87	458.64	602.87	300	155.77	2.94	0.48	307.20	151.44
15.27	427.91	20.09	1419.28	143.17	301.50	458.33	601.50	300	156.83	2.92	0.47	307.58	150.75
15.46	430.38	20.34	1423.73	142.37	302.29	459.92	602.29	300	157.63	2.92	0.47	308.77	151.15
15.87	432.69	20.88	1433.44	142.11	301.85	459.74	601.85	300	157.89	2.91	0.47	308.81	150.93
16.07	431.93	21.14	1438.22	142.11	300.32	458.21	600.32	300	157.89	2.90	0.47	308.05	150.16
16.28	435.95	21.42	1443.28	140.25	302.05	461.80	602.05	300	159.75	2.89	0.46	310.77	151.03
16.48	437.83	21.68	1448.13	139.72	302.34	462.62	602.34	300	160.28	2.89	0.46	311.45	151.17
16.68	438.46	21.95	1453.01	138.39	301.76	463.37	601.76	300	161.61	2.87	0.46	312.49	150.88
16.87	439.90	22.20	1457.68	138.13	301.78	463.65	601.78	300	161.87	2.86	0.46	312.76	150.89
17.09	442.35	22.49	1463.13	138.39	302.33	463.94	602.33	300	161.61	2.87	0.46	312.77	151.17
17.70	443.52	23.29	1478.43	138.13	299.99	461.86	599.99	300	161.87	2.85	0.46	311.86	150.00
17.91	445.94	23.57	1483.78	137.60	300.54	462.94	600.54	300	162.40	2.85	0.46	312.67	150.27
18.11	447.92	23.83	1488.91	137.80	300.84	463.03	600.84	300	162.20	2.85	0.46	312.61	150.42
18.31	448.63	24.09	1494.07	137.60	300.27	462.67	600.27	300	162.40	2.85	0.46	312.53	150.14
18.51	450.26	24.36	1499.26	136.80	300.32	463.52	600.32	300	163.20	2.84	0.46	313.36	150.16

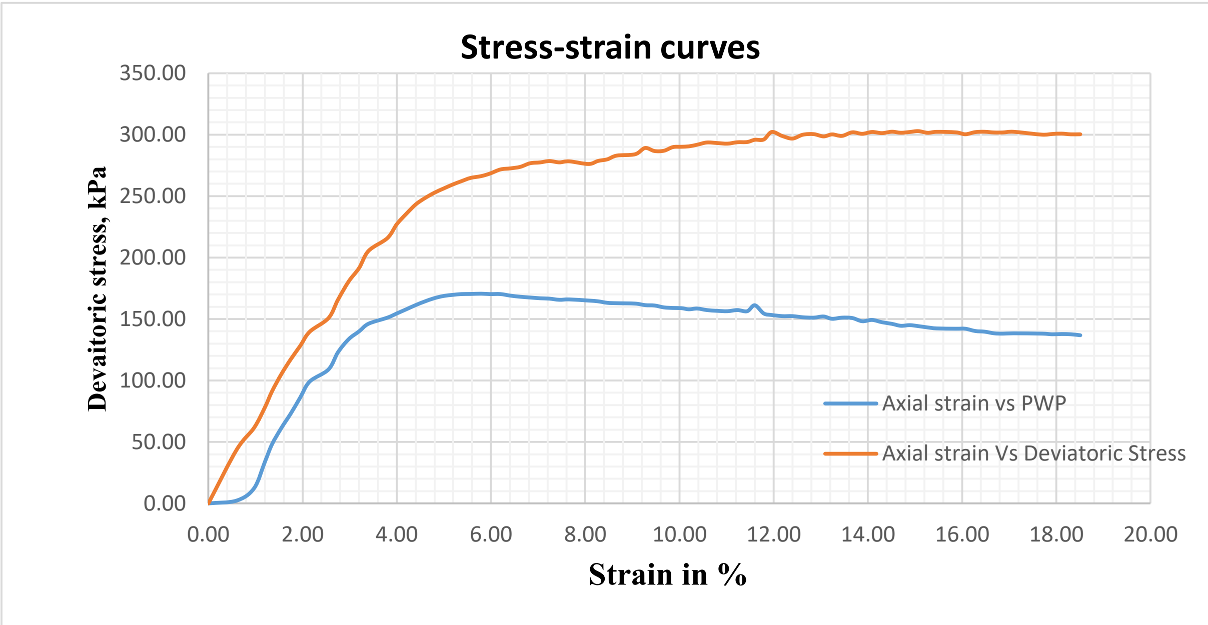


Fig C.5- Stress-strain Curve for effective consolidation pressure of 300 kPa and strain rate of 0.001mm/min

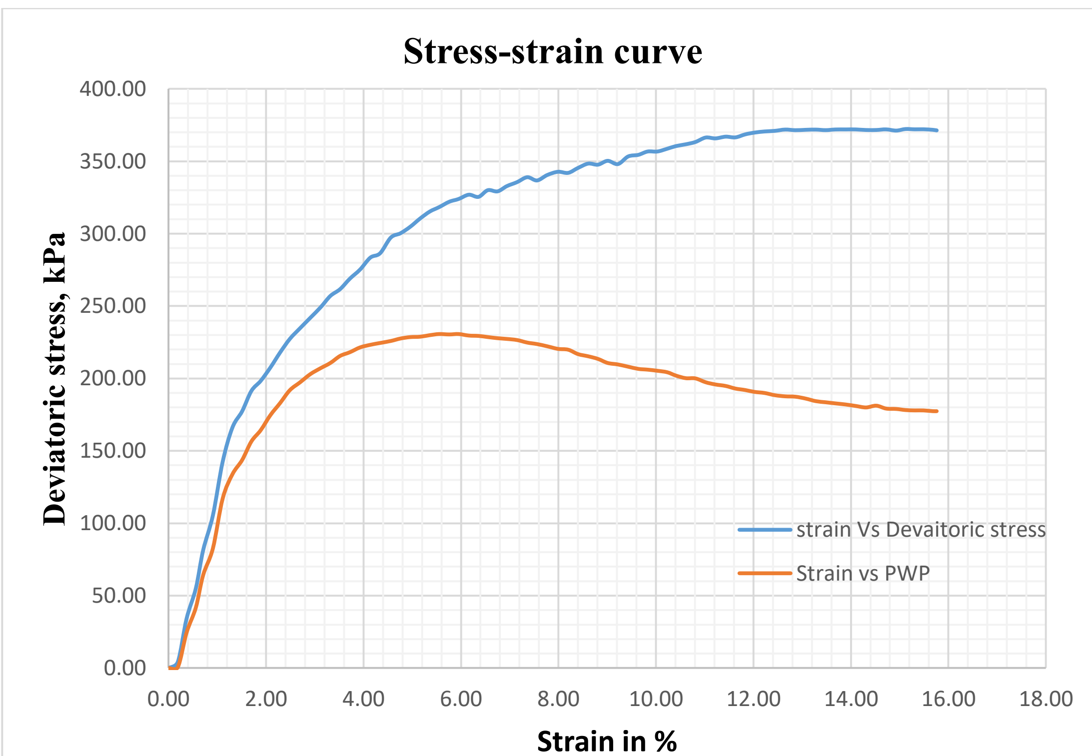


Fig C.6- Stress-strain Curve for effective consolidation pressure of 400 kPa and strain rate of 0.001mm/min

Table C4. Compression stage result for 400 kPa effective consolidation pressure													
Location		Asela kebele 09 (chigign mefelfeya area						Job reference			thesis research		
soil Description		red brown clay						Pit number			1		
Test method		CU with measurement of pore water pressure; BS 1377: clause 8						sample no			1		
								depth			3.00m		
Area in mm2	1134.115	Strain rate, mm/min		0.001							Effective stress (kPa)		400
Axial Disp. (mm)	Change in Force (N)	Axial strain (%)	Area corrected (mm²)	Change in pore pr. (kPa)	Deviator stress (kPa)	Principle stresses: Major (σ_1') (kPa)	major(σ1) (kPa)	minor (σ3) kPa	Minor (σ_3') (kPa)	σ_1'/σ_3' (-)'	Coefficient A (-)	Stress path parameters: s' (kPa)	t (kPa)
0.00	0.00	0.00	1134.11	0.00	0.00	400.00	400.00	400	400.00	1.00	-	400.00	0.00
0.19	4.80	0.25	1136.96	0.59	4.22	403.63	404.22	400	399.41	1.01	0.14	401.52	2.11
0.37	38.89	0.49	1139.66	24.46	34.13	409.67	434.13	400	375.54	1.09	0.72	392.60	17.06
0.56	62.93	0.74	1142.53	41.79	55.08	413.29	455.08	400	358.21	1.15	0.76	385.75	27.54
0.71	93.19	0.93	1144.81	64.21	81.40	417.19	481.40	400	335.79	1.24	0.79	376.49	40.70
0.91	121.08	1.20	1147.86	82.68	105.48	422.80	505.48	400	317.32	1.33	0.78	370.06	52.74
1.11	163.86	1.46	1150.92	116.97	142.37	425.40	542.37	400	283.03	1.50	0.82	354.22	71.19
1.31	191.63	1.72	1154.01	133.80	166.05	432.25	566.05	400	266.20	1.62	0.81	349.23	83.03
1.51	205.23	1.99	1157.10	143.68	177.36	433.68	577.36	400	256.32	1.69	0.81	345.00	88.68
1.70	222.04	2.24	1160.06	156.52	191.40	434.88	591.40	400	243.48	1.79	0.82	339.18	95.70
1.89	230.63	2.49	1163.04	164.23	198.30	434.07	598.30	400	235.77	1.84	0.83	334.92	99.15
2.09	242.06	2.75	1166.19	174.68	207.57	432.89	607.57	400	225.32	1.92	0.84	329.10	103.78
2.29	254.91	3.01	1169.35	183.07	217.99	434.92	617.99	400	216.93	2.00	0.84	325.92	108.99
2.49	266.61	3.28	1172.53	191.95	227.38	435.43	627.38	400	208.05	2.09	0.84	321.74	113.69
2.70	276.06	3.55	1175.89	197.39	234.77	437.38	634.77	400	202.61	2.16	0.84	319.99	117.38
2.91	285.32	3.83	1179.27	203.02	241.94	438.92	641.94	400	196.98	2.23	0.84	317.95	120.97
3.12	294.67	4.11	1182.67	207.11	249.15	442.04	649.15	400	192.89	2.29	0.83	317.47	124.58
3.32	304.77	4.37	1185.92	210.70	256.99	446.29	656.99	400	189.30	2.36	0.82	317.80	128.50
3.52	311.19	4.63	1189.19	215.56	261.69	446.13	661.69	400	184.44	2.42	0.82	315.28	130.84
3.72	320.66	4.89	1192.48	218.12	268.90	450.78	668.90	400	181.88	2.48	0.81	316.33	134.45

3.93	329.18	5.17	1195.96	221.45	275.24	453.79	675.24	400	178.55	2.54	0.80	316.17	137.62
4.14	339.99	5.45	1199.45	223.24	283.45	460.21	683.45	400	176.76	2.60	0.79	318.49	141.73
4.34	374.56	5.71	1202.80	224.52	311.40	486.88	711.40	400	175.48	2.77	0.72	331.18	155.70
4.56	358.69	6.00	1206.51	225.89	297.30	471.41	697.30	400	174.11	2.71	0.76	322.76	148.65
4.76	363.33	6.26	1209.89	227.60	300.30	472.70	700.30	400	172.40	2.74	0.76	322.55	150.15
4.96	369.81	6.53	1213.30	228.58	304.79	476.21	704.79	400	171.42	2.78	0.75	323.82	152.40
5.16	377.70	6.79	1216.72	228.84	310.43	481.59	710.43	400	171.16	2.81	0.74	326.37	155.21
5.36	384.69	7.05	1220.17	229.90	315.28	485.38	715.28	400	170.10	2.85	0.73	327.74	157.64
5.55	389.43	7.30	1223.46	230.67	318.30	487.63	718.30	400	169.33	2.88	0.72	328.48	159.15
5.76	395.19	7.58	1227.12	230.41	322.05	491.64	722.05	400	169.59	2.90	0.72	330.62	161.03
5.95	398.58	7.83	1230.45	230.67	323.93	493.26	723.93	400	169.33	2.91	0.71	331.30	161.97
6.16	403.46	8.11	1234.15	229.64	326.91	497.27	726.91	400	170.36	2.92	0.70	333.82	163.46
6.36	402.79	8.37	1237.69	229.39	325.43	496.04	725.43	400	170.61	2.91	0.70	333.33	162.72
6.55	409.60	8.62	1241.08	228.60	330.03	501.43	730.03	400	171.40	2.93	0.69	336.42	165.02
6.75	409.76	8.88	1244.66	227.81	329.21	501.40	729.21	400	172.19	2.91	0.69	336.80	164.61
6.94	415.40	9.13	1248.08	227.31	332.83	505.52	732.83	400	172.69	2.93	0.68	339.10	166.41
7.15	420.12	9.41	1251.89	226.54	335.59	509.05	735.59	400	173.46	2.93	0.68	341.25	167.79
7.36	425.68	9.68	1255.72	224.78	338.99	514.21	738.99	400	175.22	2.93	0.66	344.72	169.50
7.56	424.12	9.95	1259.39	223.75	336.77	513.02	736.77	400	176.25	2.91	0.66	344.63	168.38
7.77	430.17	10.22	1263.27	222.22	340.52	518.30	740.52	400	177.78	2.92	0.65	348.04	170.26
7.99	434.38	10.51	1267.35	220.43	342.74	522.31	742.74	400	179.57	2.91	0.64	350.94	171.37
8.20	434.78	10.79	1271.28	219.86	342.01	522.15	742.01	400	180.14	2.90	0.64	351.14	171.00
8.40	440.39	11.05	1275.04	216.84	345.39	528.55	745.39	400	183.16	2.89	0.63	355.85	172.69
8.61	445.60	11.33	1279.01	215.31	348.39	533.08	748.39	400	184.69	2.89	0.62	358.89	174.20
8.81	445.99	11.59	1282.82	213.51	347.66	534.15	747.66	400	186.49	2.86	0.61	360.32	173.83
9.01	450.74	11.86	1286.65	210.70	350.32	539.62	750.32	400	189.30	2.85	0.60	364.46	175.16
9.22	449.25	12.13	1290.70	209.67	348.07	538.40	748.07	400	190.33	2.83	0.60	364.37	174.04
9.43	457.47	12.41	1294.77	208.14	353.32	545.18	753.32	400	191.86	2.84	0.59	368.52	176.66
9.64	460.39	12.68	1298.87	206.60	354.45	547.85	754.45	400	193.40	2.83	0.58	370.63	177.23
9.83	464.70	12.93	1302.60	206.09	356.75	550.66	756.75	400	193.91	2.84	0.58	372.29	178.38
10.03	466.10	13.20	1306.54	205.32	356.74	551.42	756.74	400	194.68	2.83	0.58	373.05	178.37
10.23	470.01	13.46	1310.52	204.30	358.65	554.35	758.65	400	195.70	2.83	0.57	375.02	179.32
10.41	473.71	13.70	1314.11	201.99	360.48	558.49	760.48	400	198.01	2.82	0.56	378.25	180.24
10.61	476.78	13.96	1318.13	200.20	361.71	561.51	761.71	400	199.80	2.81	0.55	380.66	180.86
10.81	480.37	14.22	1322.18	200.04	363.32	563.28	763.32	400	199.96	2.82	0.55	381.62	181.66

11.02	486.00	14.50	1326.45	197.39	366.39	569.00	766.39	400	202.61	2.81	0.54	385.81	183.20
11.22	486.72	14.76	1330.55	195.85	365.80	569.95	765.80	400	204.15	2.79	0.54	387.05	182.90
11.43	489.89	15.04	1334.87	194.83	367.00	572.17	767.00	400	205.17	2.79	0.53	388.67	183.50
11.63	490.75	15.30	1339.02	193.03	366.50	573.47	766.50	400	206.97	2.77	0.53	390.22	183.25
11.83	495.05	15.57	1343.19	192.01	368.56	576.55	768.56	400	207.99	2.77	0.52	392.27	184.28
12.02	498.19	15.82	1347.18	190.73	369.80	579.07	769.80	400	209.27	2.77	0.52	394.17	184.90
12.23	500.91	16.09	1351.62	189.96	370.60	580.64	770.60	400	210.04	2.76	0.51	395.34	185.30
12.44	503.13	16.37	1356.08	188.43	371.02	582.59	771.02	400	211.57	2.75	0.51	397.08	185.51
12.65	506.01	16.64	1360.58	187.66	371.90	584.24	771.90	400	212.34	2.75	0.50	398.29	185.95
12.86	507.10	16.92	1365.11	187.40	371.47	584.07	771.47	400	212.60	2.75	0.50	398.34	185.74
13.07	509.15	17.20	1369.66	186.12	371.73	585.61	771.73	400	213.88	2.74	0.50	399.75	185.87
13.28	511.05	17.47	1374.25	184.33	371.88	587.55	771.88	400	215.67	2.72	0.50	401.61	185.94
13.48	512.17	17.74	1378.64	183.56	371.50	587.94	771.50	400	216.44	2.72	0.49	402.19	185.75
13.68	514.43	18.00	1383.07	182.79	371.95	589.16	771.95	400	217.21	2.71	0.49	403.18	185.97
13.89	516.23	18.28	1387.74	182.03	371.99	589.96	771.99	400	217.97	2.71	0.49	403.97	186.00
14.10	517.98	18.55	1392.45	181.00	371.99	590.99	771.99	400	219.00	2.70	0.49	405.00	186.00
14.31	519.19	18.83	1397.19	179.98	371.60	591.62	771.60	400	220.02	2.69	0.48	405.82	185.80
14.52	520.98	19.11	1401.96	181.21	371.61	590.40	771.61	400	218.79	2.70	0.49	404.60	185.81
14.72	523.28	19.37	1406.54	179.21	372.03	592.82	772.03	400	220.79	2.69	0.48	406.81	186.02
14.93	523.91	19.64	1411.38	178.95	371.21	592.26	771.21	400	221.05	2.68	0.48	406.65	185.60
15.12	527.04	19.89	1415.78	178.19	372.26	594.07	772.26	400	221.81	2.68	0.48	407.94	186.13
15.31	528.40	20.14	1420.21	177.93	372.06	594.13	772.06	400	222.07	2.68	0.48	408.10	186.03
15.49	530.03	20.38	1424.44	177.93	372.10	594.17	772.10	400	222.07	2.68	0.48	408.12	186.05
15.68	531.17	20.63	1428.92	177.41	371.72	594.31	771.72	400	222.59	2.67	0.48	408.45	185.86
15.76	531.31	20.74	1430.82	177.41	371.33	593.92	771.33	400	222.59	2.67	0.48	408.25	185.66
15.76	531.33	20.74	1430.82	177.41	371.34	593.93	771.34	400	222.59	2.67	0.48	408.26	185.67

1.2) Triaxial compression test result for strain rate 0.01mm/min

Table C5: consolidation Stage result for effective consolidation pressure of 200kPa, 300kPa and 400kPa

Location: Asela kebele 09 (chigign mefelfeya)						Job reference		Thesis research
Soil Description: Red brown Clay						pit No		#1
Test Method: CU with pore water pressure measurement, BS 1377,clause 8						sample No		#1
						Depth		2.8m
Remolded soil								
Effective consolidation pressure of 200 kPa			Effective consolidation pressure of 300 kPa			Effective consolidation pressure of 400 kPa		
Initial condition	CP,kPa	500	Initial condition	CP,kPa	700	Initial condition	CP,Kpa	700
	BP,kPa	300		BP,kPa	400		BP,kPa	300
	PP,kPa	424.55		PP,kPa	536.72		PP,kPa	646.61
Final condition	PP,kPa	246.44	Final condition	PP,kPa	264.52	Final condition	PP,kPa	275.08
	∆volume,	3.95		∆volum	4.63		∆volume	5.81
	%consolidation	98.9		%consolidation	98		%consolidation	98.56
Sqrt of time	∆volume, mm	PP,kPa	Sqrt of time	∆volume,mm	PP,kPa	Sqrt of time	∆volume ,mm	PP,kPa
0.00	3.95	424.55	0.29	4.58	536.72	0.360	5.80	646.35
0.44	3.25	248.04	0.36	4.13	536.88	0.440	5.18	276.28
0.54	3.23	247.00	0.44	3.93	264.35	0.540	5.18	275.60
0.66	3.19	309.37	0.54	3.89	264.02	0.660	5.03	275.17
0.81	3.14	309.18	0.66	3.85	263.53	0.810	4.95	274.83
1.00	3.09	309.08	0.81	3.79	263.36	1.000	4.84	274.66
1.22	3.03	309.08	1.00	3.71	263.3	1.220	4.73	274.48
1.49	2.97	308.99	1.22	3.66	263.2	1.490	4.68	274.31
1.83	2.93	308.79	1.49	3.59	263.11	1.830	4.53	274.92
2.24	2.84	308.70	1.83	3.51	262.95	2.240	4.42	273.97
2.74	2.79	308.51	2.24	3.39	262.95	2.740	4.38	273.97
3.36	2.66	308.51	2.74	3.27	262.8	3.360	4.20	273.88
4.11	2.48	308.60	3.36	3.11	262.86	4.110	3.96	273.80
5.04	2.34	308.51	4.11	2.96	262.78	5.040	3.65	273.97
6.17	2.11	308.51	5.04	2.73	262.86	6.170	3.39	274.05
7.56	1.82	308.79	6.17	2.53	262.95	7.560	3.00	274.40
9.26	1.48	308.60	7.56	2.23	262.95	9.260	2.67	274.57
11.34	1.15	308.60	9.26	1.83	263.21	11.340	2.17	274.92
13.89	0.84	308.79	11.34	1.39	263.21	13.890	1.67	275.17
17.01	0.57	308.79	13.89	0.95	263.3	17.010	1.25	275.60
20.83	0.24	308.51	17.01	0.49	263.1	20.830	0.81	275.86
25.51	0.06	308.41	20.83	0.22	263.25	25.510	0.43	275.60
31.25	0.00	307.83	25.51	0.15	264.52	31.250	0.32	275.08

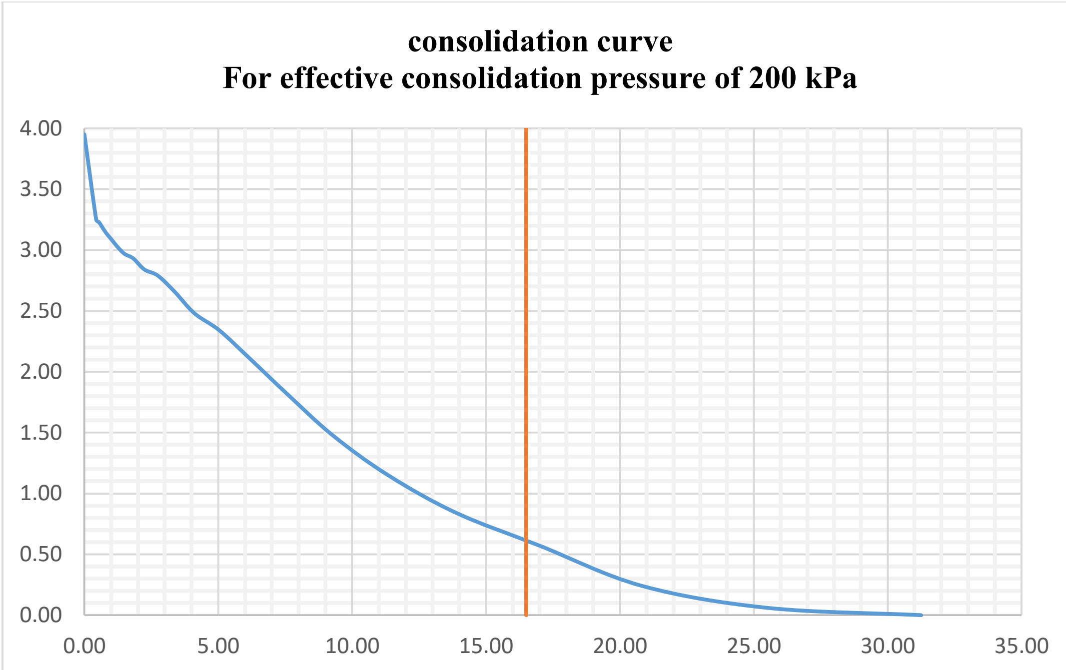


Fig C.7. Consolidation curve for effective consolidation pressure of 200 kPa

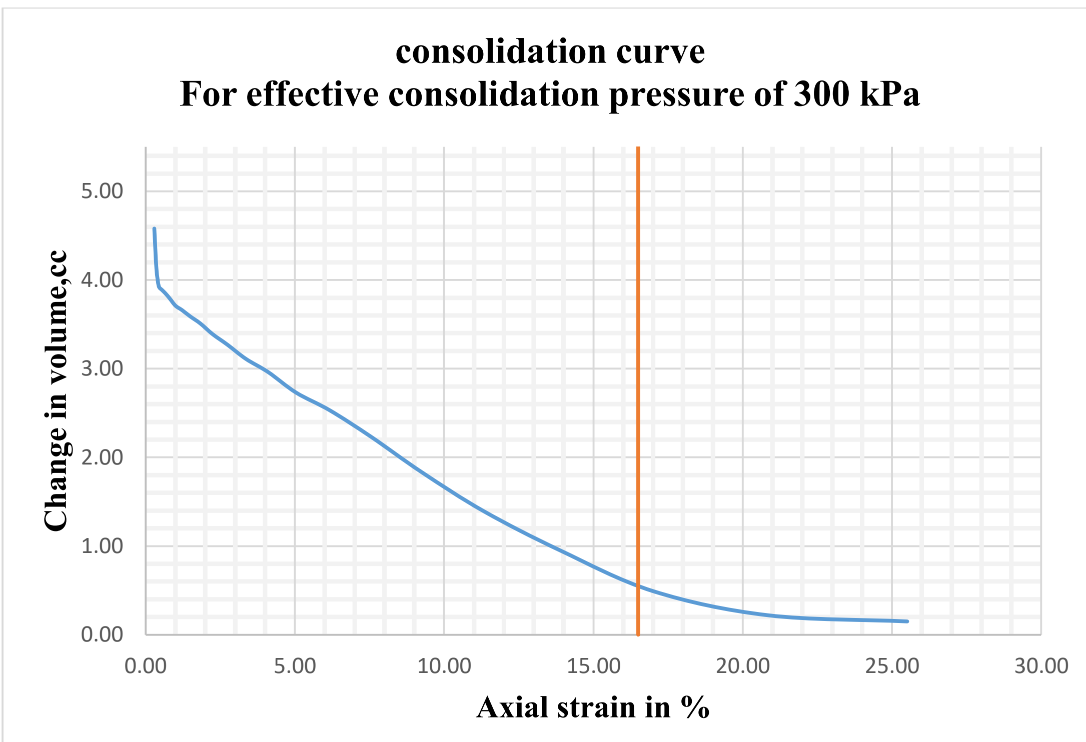


Fig C.8. Consolidation curve for effective consolidation pressure of 300 kPa

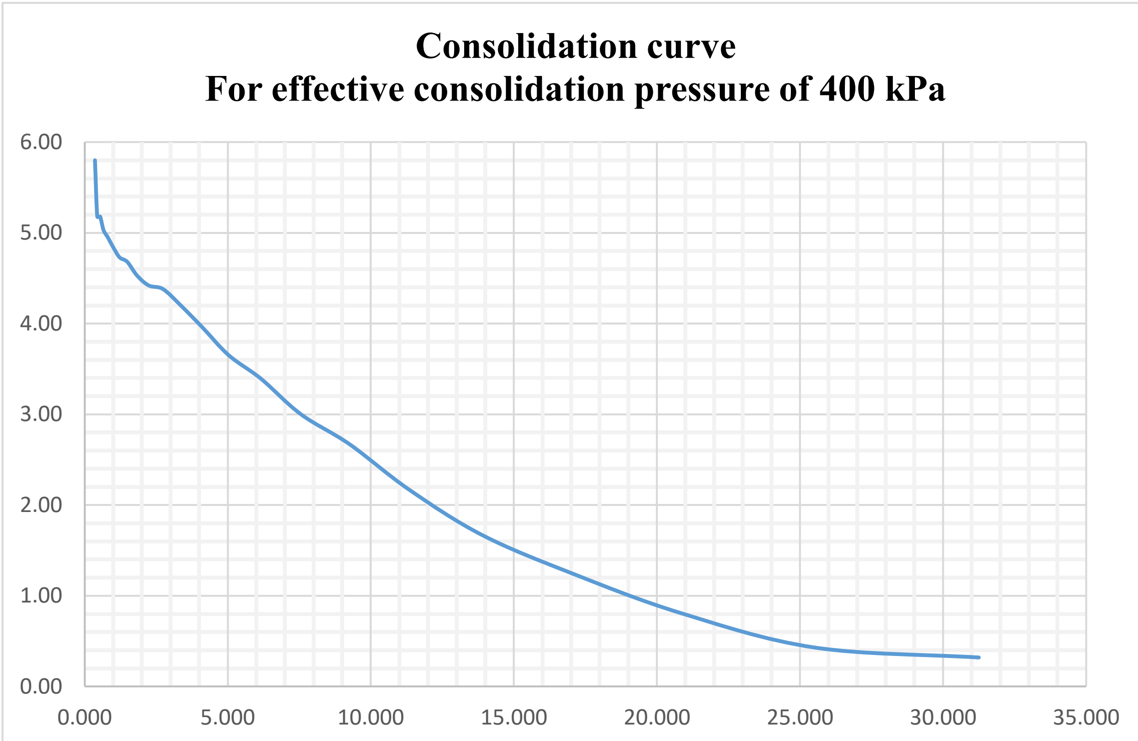


Fig C.9. Consolidation curve for effective consolidation pressure of 400 kPa

Table C6. Compression stage result for 200 kPa effective consolidation pressure													
Location			Asela kebele 09 (chigign mefelfeya area)					Job reference		thesis research			
soil Description			Red brown clay					Pit number		1			
Test method			CU with measurement of pore water pressure; BS 1377: clause 8					sample no		1			
								depth		3.00m			
Area in mm2		1134.11	strain rate(mm/min)			0.01		Effective stress (kPa)					200
						Principle stresses					Coefficient	Stress path parameters	
Axial Disp. (mm)	Change in force (N)	Axial strain (%)	Area corrected (mm^2)	Change in pore pr. (kPa)	Deviator stress (kPa)	Major (σ_1') (kPa)	major(σ_1) (kPa)	minor (σ_3) kPa	Minor (σ_3') (kPa)	σ_1'/σ_3' (-)'	A (-)	s' (kPa)	T (kPa)
0.00	0.00	0.00	1134.11	0.00	0.00	200.00	200.00	200	200.00	1.00	-	200.00	0.00
0.20	0.53	0.26	1137.11	5.84	0.47	194.63	200.47	200	194.16	1.00	12.53	194.39	0.23
0.31	7.91	0.41	1138.76	6.65	6.95	200.30	206.95	200	193.35	1.04	0.96	196.82	3.47
0.39	40.71	0.51	1139.96	8.72	35.71	226.99	235.71	200	191.28	1.19	0.24	209.14	17.86
0.47	64.62	0.62	1141.17	10.15	56.63	246.48	256.63	200	189.85	1.30	0.18	218.16	28.31
0.55	76.71	0.72	1142.38	12.27	67.15	254.88	267.15	200	187.73	1.36	0.18	221.31	33.58
0.63	87.02	0.83	1143.59	13.02	76.10	263.08	276.10	200	186.98	1.41	0.17	225.03	38.05
0.74	96.18	0.97	1145.27	14.45	83.98	269.53	283.98	200	185.55	1.45	0.17	227.54	41.99
0.84	104.44	1.11	1146.79	16.17	91.08	274.91	291.08	200	183.83	1.50	0.18	229.37	45.54
0.94	113.33	1.24	1148.32	18.46	98.70	280.24	298.70	200	181.54	1.54	0.19	230.89	49.35
1.04	118.49	1.37	1149.85	21.32	103.05	281.73	303.05	200	178.68	1.58	0.21	230.20	51.52
1.14	126.76	1.50	1151.39	24.19	110.09	285.90	310.09	200	175.81	1.63	0.22	230.85	55.04
1.24	128.36	1.63	1152.93	25.91	111.33	285.42	311.33	200	174.09	1.64	0.23	229.76	55.67
1.34	137.24	1.76	1154.47	28.48	118.88	290.40	318.88	200	171.52	1.69	0.24	230.96	59.44
1.44	144.36	1.89	1156.02	33.35	124.87	291.52	324.87	200	166.65	1.75	0.27	229.09	62.44
1.56	152.18	2.05	1157.88	36.79	131.43	294.64	331.43	200	163.21	1.81	0.28	228.92	65.71
1.66	158.84	2.18	1159.44	39.65	137.00	297.35	337.00	200	160.35	1.85	0.29	228.85	68.50
1.77	167.73	2.33	1161.16	42.80	144.45	301.65	344.45	200	157.20	1.92	0.30	229.43	72.23
1.88	172.44	2.47	1162.88	45.09	148.29	303.20	348.29	200	154.91	1.96	0.30	229.06	74.15
1.99	176.44	2.62	1164.61	48.82	151.51	302.69	351.51	200	151.18	2.00	0.32	226.93	75.75
2.09	182.49	2.75	1166.19	52.25	156.48	304.23	356.48	200	147.75	2.06	0.33	225.99	78.24

2.20	187.38	2.89	1167.92	54.83	160.44	305.61	360.44	200	145.17	2.11	0.34	225.39	80.22
2.31	190.58	3.04	1169.67	59.13	162.93	303.80	362.93	200	140.87	2.16	0.36	222.34	81.47
2.41	196.09	3.17	1171.26	62.28	167.42	305.14	367.42	200	137.72	2.22	0.37	221.43	83.71
2.51	199.91	3.30	1172.85	66.86	170.45	303.59	370.45	200	133.14	2.28	0.39	218.36	85.22
2.62	204.62	3.45	1174.61	70.87	174.20	303.33	374.20	200	129.13	2.35	0.41	216.23	87.10
2.71	209.24	3.57	1176.05	73.73	177.92	304.19	377.92	200	126.27	2.41	0.41	215.23	88.96
2.81	212.62	3.70	1177.66	76.59	180.55	303.96	380.55	200	123.41	2.46	0.42	213.68	90.27
2.90	215.56	3.82	1179.11	80.32	182.81	302.49	382.81	200	119.68	2.53	0.44	211.09	91.41
2.98	215.56	3.92	1180.40	82.61	182.61	300.00	382.61	200	117.39	2.56	0.45	208.70	91.31
3.09	220.26	4.07	1182.18	85.47	186.32	300.85	386.32	200	114.53	2.63	0.46	207.69	93.16
3.21	221.60	4.22	1184.13	87.48	187.14	299.66	387.14	200	112.52	2.66	0.47	206.09	93.57
3.34	224.98	4.39	1186.25	89.77	189.66	299.89	389.66	200	110.23	2.72	0.47	205.06	94.83
3.45	226.93	4.54	1188.05	92.35	191.01	298.66	391.01	200	107.65	2.77	0.48	203.16	95.51
3.55	230.31	4.67	1189.69	93.49	193.59	300.10	393.59	200	106.51	2.82	0.48	203.30	96.79
3.65	232.36	4.80	1191.33	95.50	195.04	299.54	395.04	200	104.50	2.87	0.49	202.02	97.52
3.74	235.02	4.92	1192.81	94.93	197.03	302.10	397.03	200	105.07	2.88	0.48	203.59	98.52
3.83	237.07	5.04	1194.30	98.65	198.50	299.85	398.50	200	101.35	2.96	0.50	200.60	99.25
3.90	238.40	5.13	1195.46	100.08	199.42	299.34	399.42	200	99.92	3.00	0.50	199.63	99.71
3.99	239.73	5.25	1196.96	101.22	200.29	299.07	400.29	200	98.78	3.03	0.51	198.92	100.14
4.08	242.40	5.37	1198.45	102.08	202.26	300.18	402.26	200	97.92	3.07	0.50	199.05	101.13
4.18	244.44	5.50	1200.12	103.23	203.68	300.45	403.68	200	96.77	3.10	0.51	198.61	101.84
4.27	244.44	5.62	1201.63	104.66	203.43	298.77	403.43	200	95.34	3.13	0.51	197.05	101.71
4.36	247.82	5.74	1203.14	106.32	205.98	299.66	405.98	200	93.68	3.20	0.52	196.67	102.99
4.47	249.78	5.88	1204.99	106.38	207.29	300.91	407.29	200	93.62	3.21	0.51	197.26	103.64
4.56	252.53	6.00	1206.51	108.38	209.31	300.93	409.31	200	91.62	3.28	0.52	196.27	104.65
4.66	253.87	6.13	1208.20	108.38	210.12	301.74	410.12	200	91.62	3.29	0.52	196.68	105.06
4.76	255.82	6.26	1209.89	109.24	211.44	302.20	411.44	200	90.76	3.33	0.52	196.48	105.72
4.87	258.58	6.41	1211.76	110.10	213.39	303.29	413.39	200	89.90	3.37	0.52	196.59	106.69
4.97	259.91	6.54	1213.47	110.67	214.19	303.52	414.19	200	89.33	3.40	0.52	196.42	107.09
5.08	262.58	6.68	1215.35	111.82	216.05	304.23	416.05	200	88.18	3.45	0.52	196.21	108.03
5.18	262.58	6.82	1217.07	111.53	215.75	304.22	415.75	200	88.47	3.44	0.52	196.34	107.87
5.29	265.24	6.96	1218.96	111.53	217.60	306.07	417.60	200	88.47	3.46	0.51	197.27	108.80
5.39	266.58	7.09	1220.69	111.82	218.38	306.56	418.38	200	88.18	3.48	0.51	197.37	109.19
5.48	268.00	7.21	1222.25	112.06	219.27	307.21	419.27	200	87.94	3.49	0.51	197.57	109.63
5.58	269.96	7.34	1223.98	112.39	220.56	308.17	420.56	200	87.61	3.52	0.51	197.89	110.28

5.69	271.29	7.49	1225.90	112.68	221.30	308.62	421.30	200	87.32	3.53	0.51	197.97	110.65
5.79	274.04	7.62	1227.64	112.39	223.23	310.84	423.23	200	87.61	3.55	0.50	199.22	111.61
5.89	277.33	7.75	1229.39	112.68	225.59	312.91	425.59	200	87.32	3.58	0.50	200.11	112.79
6.00	275.38	7.89	1231.32	112.68	223.64	310.96	423.64	200	87.32	3.56	0.50	199.14	111.82
6.08	279.38	8.00	1232.73	112.63	226.63	314.00	426.63	200	87.37	3.59	0.50	200.69	113.32
6.19	283.47	8.14	1234.68	112.68	229.59	316.91	429.59	200	87.32	3.63	0.49	202.11	114.79
6.29	283.47	8.28	1236.45	112.68	229.26	316.58	429.26	200	87.32	3.63	0.49	201.95	114.63
6.40	286.13	8.42	1238.40	112.11	231.05	318.94	431.05	200	87.89	3.63	0.49	203.42	115.53
6.52	286.13	8.58	1240.54	112.39	230.65	318.26	430.65	200	87.61	3.63	0.49	202.94	115.33
6.63	285.42	8.72	1242.51	112.11	229.71	317.60	429.71	200	87.89	3.61	0.49	202.75	114.86
6.73	288.09	8.86	1244.30	111.53	231.53	320.00	431.53	200	88.47	3.62	0.48	204.23	115.76
6.84	289.51	9.00	1246.28	110.67	232.30	321.63	432.30	200	89.33	3.60	0.48	205.48	116.15
6.95	290.13	9.14	1248.27	110.67	232.43	321.76	432.43	200	89.33	3.60	0.48	205.54	116.21
7.06	291.47	9.29	1250.26	109.82	233.13	323.31	433.13	200	90.18	3.59	0.47	206.74	116.56
7.17	292.80	9.43	1252.26	108.82	233.82	325.00	433.82	200	91.18	3.56	0.47	208.09	116.91
7.28	294.22	9.58	1254.26	109.24	234.58	325.34	434.58	200	90.76	3.58	0.47	208.05	117.29
7.38	293.51	9.71	1256.09	109.24	233.67	324.43	433.67	200	90.76	3.57	0.47	207.60	116.84
7.49	294.84	9.86	1258.10	109.24	234.36	325.12	434.36	200	90.76	3.58	0.47	207.94	117.18
7.59	294.84	9.99	1259.94	108.38	234.01	325.63	434.01	200	91.62	3.55	0.46	208.63	117.01
7.67	297.51	10.09	1261.42	108.67	235.85	327.18	435.85	200	91.33	3.58	0.46	209.26	117.93
7.75	298.84	10.20	1262.90	108.38	236.63	328.25	436.63	200	91.62	3.58	0.46	209.94	118.32
7.85	296.89	10.33	1264.75	108.38	234.74	326.36	434.74	200	91.62	3.56	0.46	208.99	117.37
7.95	300.89	10.46	1266.61	107.52	237.55	330.03	437.55	200	92.48	3.57	0.45	211.26	118.78
8.07	302.93	10.62	1268.85	108.67	238.75	330.08	438.75	200	91.33	3.61	0.46	210.70	119.37
8.17	303.56	10.75	1270.72	107.81	238.89	331.08	438.89	200	92.19	3.59	0.45	211.63	119.44
8.29	305.60	10.91	1272.97	107.24	240.07	332.83	440.07	200	92.76	3.59	0.45	212.79	120.03
8.40	308.98	11.05	1275.04	107.81	242.33	334.52	442.33	200	92.19	3.63	0.44	213.35	121.16
8.51	308.27	11.20	1277.12	107.81	241.38	333.57	441.38	200	92.19	3.62	0.45	212.88	120.69
8.62	308.27	11.34	1279.20	108.10	240.98	332.88	440.98	200	91.90	3.62	0.45	212.39	120.49
8.72	308.27	11.47	1281.10	107.52	240.63	333.11	440.63	200	92.48	3.60	0.45	212.79	120.31
8.80	309.60	11.58	1282.63	107.52	241.38	333.86	441.38	200	92.48	3.61	0.45	213.17	120.69
8.89	312.98	11.70	1284.35	106.67	243.69	337.02	443.69	200	93.33	3.61	0.44	215.17	121.84
8.97	312.36	11.80	1285.88	106.67	242.91	336.24	442.91	200	93.33	3.60	0.44	214.79	121.46
9.06	312.36	11.92	1287.61	107.24	242.59	335.35	442.59	200	92.76	3.62	0.44	214.05	121.29
9.16	313.69	12.05	1289.54	107.24	243.26	336.02	443.26	200	92.76	3.62	0.44	214.39	121.63

9.24	312.98	12.16	1291.08	107.24	242.41	335.17	442.41	200	92.76	3.61	0.44	213.97	121.21
9.34	315.64	12.29	1293.02	107.24	244.11	336.87	444.11	200	92.76	3.63	0.44	214.82	122.06
9.43	316.36	12.41	1294.77	106.38	244.33	337.95	444.33	200	93.62	3.61	0.44	215.79	122.17
9.52	318.40	12.53	1296.52	106.67	245.58	338.91	445.58	200	93.33	3.63	0.43	216.12	122.79
9.63	321.07	12.67	1298.67	105.81	247.23	341.42	447.23	200	94.19	3.62	0.43	217.80	123.61
9.73	322.58	12.80	1300.63	106.38	248.02	341.64	448.02	200	93.62	3.65	0.43	217.63	124.01
9.83	326.84	12.93	1302.60	106.09	250.92	344.83	450.92	200	93.91	3.67	0.42	219.37	125.46
9.94	326.22	13.08	1304.76	106.38	250.02	343.64	450.02	200	93.62	3.67	0.43	218.63	125.01
10.05	327.56	13.22	1306.94	106.38	250.63	344.25	450.63	200	93.62	3.68	0.42	218.94	125.32
10.15	328.20	13.36	1308.93	107.41	250.74	343.33	450.74	200	92.59	3.71	0.43	217.96	125.37

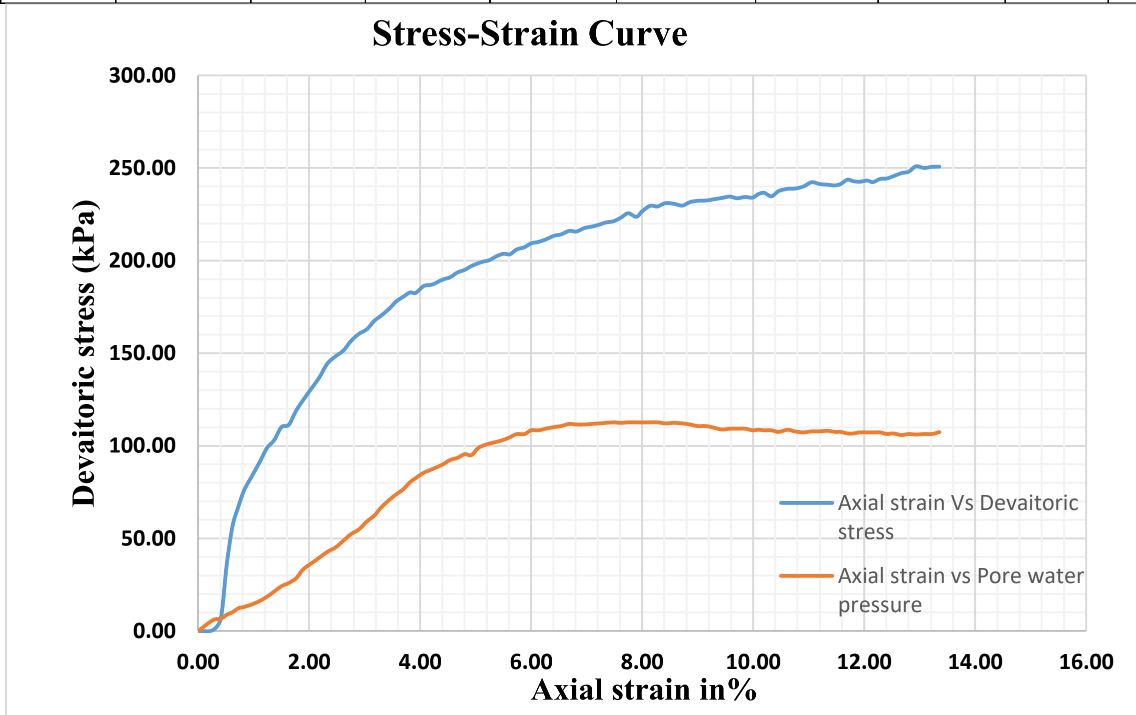


Fig C.10- Stress-strain Curve for effective consolidation pressure of 200 kPa and strain rate of 0.01mm/min

Table C7. Compression stage result for 300 kPa effective consolidation pressure													
Location		Asela kebele 09 (chigign mefelfeya area						Job reference			thesis research		
soil Description		Red brown clay						Pit number			1		
Test method		CU with measurement of pore water pressure; BS 1377: clause 8						sample no			1		
								depth			3.00m		
Area in mm2	1134.1	strain rate in mm/min			0.01			Effective stress (kPa)			300		
Axial Disp. (mm)	Change in force (N)	Axial strain (%)	Area corrected (mm²)	Change in pore pr. (kPa)	Deviato stress (kPa)	Principle stresses: Major (σ1') (kPa)	major(σ1) (kpa)	minor (σ3) Kpa	Minor (σ3') (kPa)	σ1'/σ3' (-)'	Coefficie A (-)	Stress path parameters: s' (kPa)	t (kPa)
0.000	0.00	0.000	1134.11	0.00	0.00	300.00	300.00	300	300.00	1.00	-	300.00	0.00
0.102	56.50	0.134	1135.64	1.16	49.76	348.60	349.76	300	298.84	1.17	0.02	323.72	24.88
0.319	74.61	0.420	1138.90	16.74	65.51	348.77	365.51	300	283.26	1.23	0.26	316.02	32.76
0.513	131.34	0.675	1141.82	25.51	115.03	389.52	415.03	300	274.49	1.42	0.22	332.00	57.51
0.726	158.02	0.955	1145.05	34.54	138.00	403.46	438.00	300	265.46	1.52	0.25	334.46	69.00
0.902	175.99	1.187	1147.74	44.97	153.33	408.36	453.33	300	255.03	1.60	0.29	331.69	76.67
1.117	193.00	1.470	1151.03	53.67	167.67	414.01	467.67	300	246.33	1.68	0.32	330.17	83.84
1.329	207.86	1.749	1154.30	62.37	180.08	417.71	480.08	300	237.63	1.76	0.35	327.67	90.04
1.553	220.82	2.043	1157.77	71.75	190.73	418.98	490.73	300	228.25	1.84	0.38	323.61	95.37
1.734	230.26	2.282	1160.59	78.53	198.39	419.86	498.39	300	221.47	1.90	0.40	320.67	99.20
1.927	243.48	2.536	1163.62	87.40	209.25	421.84	509.25	300	212.60	1.98	0.42	317.22	104.62
2.138	254.80	2.813	1166.94	95.40	218.35	422.95	518.35	300	204.60	2.07	0.44	313.78	109.18
2.331	268.18	3.067	1170.00	105.14	229.21	424.07	529.21	300	194.86	2.18	0.46	309.47	114.61
2.512	277.50	3.305	1172.88	111.40	236.60	425.19	536.60	300	188.60	2.25	0.47	306.89	118.30
2.736	290.69	3.600	1176.47	120.79	247.09	426.30	547.09	300	179.21	2.38	0.49	302.76	123.54
2.926	299.74	3.850	1179.53	126.70	254.11	427.41	554.11	300	173.30	2.47	0.50	300.35	127.06
3.129	310.12	4.117	1182.81	133.65	262.19	428.53	562.19	300	166.35	2.58	0.51	297.44	131.09
3.333	319.74	4.386	1186.13	139.92	269.56	429.64	569.56	300	160.08	2.68	0.52	294.86	134.78
3.552	328.64	4.674	1189.72	145.48	276.23	430.75	576.23	300	154.52	2.79	0.53	292.63	138.12
3.749	335.43	4.933	1192.96	149.31	281.18	431.87	581.18	300	150.69	2.87	0.53	291.28	140.59

3.936	340.14	5.179	1196.06	151.40	284.38	432.99	584.38	300	148.60	2.91	0.53	290.80	142.19
4.156	346.68	5.468	1199.72	154.87	288.96	434.10	588.96	300	145.13	2.99	0.54	289.61	144.48
4.348	351.46	5.721	1202.94	156.96	292.17	435.21	592.17	300	143.04	3.04	0.54	289.12	146.08
4.532	355.27	5.963	1206.03	158.70	294.58	435.88	594.58	300	141.30	3.08	0.54	288.59	147.29
4.766	360.03	6.271	1209.99	160.09	297.55	437.46	597.55	300	139.91	3.13	0.54	288.69	148.77
4.956	363.68	6.521	1213.23	160.77	299.76	438.99	599.76	300	139.23	3.15	0.54	289.11	149.88
5.180	365.25	6.816	1217.07	161.83	300.11	438.28	600.11	300	138.17	3.17	0.54	288.22	150.05
5.387	368.38	7.088	1220.64	160.77	301.79	441.02	601.79	300	139.23	3.17	0.53	290.12	150.90
5.575	368.58	7.336	1223.89	160.77	301.15	440.38	601.15	300	139.23	3.16	0.53	289.80	150.58
5.793	370.07	7.622	1227.69	160.77	301.43	440.66	601.43	300	139.23	3.17	0.53	289.94	150.72
5.984	370.01	7.874	1231.04	160.08	300.56	440.48	600.56	300	139.92	3.15	0.53	290.20	150.28
6.099	367.73	8.025	1233.07	160.08	298.23	438.15	598.23	300	139.92	3.13	0.54	289.03	149.11
6.221	372.53	8.186	1235.22	158.69	301.59	442.89	601.59	300	141.31	3.13	0.53	292.10	150.79
6.423	374.44	8.451	1238.81	159.39	302.26	442.87	602.26	300	140.61	3.15	0.53	291.74	151.13
6.649	378.25	8.749	1242.85	157.29	304.34	447.05	604.34	300	142.71	3.13	0.52	294.88	152.17
6.834	378.79	8.992	1246.17	157.29	303.97	446.67	603.97	300	142.71	3.13	0.52	294.69	151.98
7.061	380.71	9.291	1250.28	157.29	304.50	447.21	604.50	300	142.71	3.13	0.52	294.96	152.25
7.259	385.91	9.551	1253.88	156.26	307.77	451.51	607.77	300	143.74	3.14	0.51	297.63	153.89
7.473	386.44	9.833	1257.79	156.26	307.24	450.98	607.24	300	143.74	3.14	0.51	297.36	153.62
7.656	385.74	10.07	1261.16	156.26	305.86	449.61	605.86	300	143.74	3.13	0.51	296.68	152.93
7.853	394.17	10.33	1264.81	155.21	311.64	456.43	611.64	300	144.79	3.15	0.50	300.61	155.82
8.087	393.40	10.64	1269.16	154.86	309.97	455.11	609.97	300	145.14	3.14	0.50	300.12	154.98
8.264	396.62	10.87	1272.48	154.52	311.69	457.17	611.69	300	145.48	3.14	0.50	301.33	155.84
8.478	397.84	11.15	1276.51	153.82	311.66	457.84	611.66	300	146.18	3.13	0.49	302.01	155.83
8.684	402.34	11.43	1280.42	153.47	314.23	460.76	614.23	300	146.53	3.14	0.49	303.64	157.11
8.889	404.26	11.70	1284.33	153.13	314.76	461.63	614.76	300	146.87	3.14	0.49	304.25	157.38
9.111	407.46	11.98	1288.59	152.78	316.21	463.43	616.21	300	147.22	3.15	0.48	305.33	158.10
9.331	409.28	12.27	1292.85	151.39	316.58	465.19	616.58	300	148.61	3.13	0.48	306.90	158.29
9.542	413.18	12.55	1296.95	151.04	318.58	467.54	618.58	300	148.96	3.14	0.47	308.25	159.29
9.739	414.41	12.81	1300.81	150.34	318.58	468.23	618.58	300	149.66	3.13	0.47	308.94	159.29
9.930	418.22	13.07	1304.57	149.65	320.58	470.93	620.58	300	150.35	3.13	0.47	310.64	160.29
10.14	419.44	13.34	1308.67	149.65	320.51	470.86	620.51	300	150.35	3.13	0.47	310.61	160.25
10.33	423.34	13.59	1312.45	149.65	322.55	472.91	622.55	300	150.35	3.15	0.46	311.63	161.28
10.53	422.99	13.86	1316.58	148.26	321.28	473.02	621.28	300	151.74	3.12	0.46	312.38	160.64

10.75	425.66	14.14	1320.90	148.26	322.25	473.99	622.25	300	151.74	3.12	0.46	312.86	161.12
10.96	428.00	14.43	1325.33	147.91	322.94	475.03	622.94	300	152.09	3.12	0.46	313.56	161.47
11.15	428.17	14.67	1329.15	147.91	322.14	474.23	622.14	300	152.09	3.12	0.46	313.16	161.07
11.34	432.03	14.92	1333.04	147.57	324.09	476.53	624.09	300	152.43	3.13	0.46	314.48	162.05
11.54	432.53	15.18	1337.09	147.57	323.49	475.92	623.49	300	152.43	3.12	0.46	314.18	161.74
11.77	434.01	15.49	1341.96	145.47	323.42	477.94	623.42	300	154.53	3.09	0.45	316.23	161.71
11.97	434.13	15.75	1346.09	146.52	322.51	475.99	622.51	300	153.48	3.10	0.45	314.74	161.26
12.16	437.79	15.99	1350.07	145.47	324.27	478.80	624.27	300	154.53	3.10	0.45	316.66	162.14
12.39	440.36	16.29	1354.91	140.00	325.01	485.01	625.01	300	160.00	3.03	0.43	322.51	162.51
12.57	438.83	16.54	1358.86	145.83	322.94	477.12	622.94	300	154.17	3.09	0.45	315.64	161.47
12.77	440.74	16.81	1363.21	145.83	323.31	477.48	623.31	300	154.17	3.10	0.45	315.83	161.66
12.90	440.65	16.97	1365.97	144.09	322.59	478.51	622.59	300	155.91	3.07	0.45	317.21	161.30
13.05	442.52	17.18	1369.31	145.13	323.17	478.04	623.17	300	154.87	3.09	0.45	316.45	161.59
13.22	442.46	17.39	1372.89	144.78	322.29	477.51	622.29	300	155.22	3.08	0.45	316.36	161.14
13.44	443.07	17.68	1377.72	143.73	321.59	477.86	621.59	300	156.27	3.06	0.45	317.06	160.80
13.62	443.00	17.93	1381.83	144.69	320.59	475.90	620.59	300	155.31	3.06	0.45	315.61	160.29
13.82	445.51	18.18	1386.16	144.09	321.40	477.31	621.40	300	155.91	3.06	0.45	316.61	160.70
14.03	446.12	18.46	1390.86	143.04	320.75	477.71	620.75	300	156.96	3.04	0.45	317.34	160.38
14.22	446.04	18.71	1395.22	142.70	319.69	476.99	619.69	300	157.30	3.03	0.45	317.15	159.85
14.42	451.13	18.98	1399.80	143.04	322.28	479.24	622.28	300	156.96	3.05	0.44	318.10	161.14
14.64	452.34	19.27	1404.80	143.04	321.99	478.95	621.99	300	156.96	3.05	0.44	317.96	161.00
14.83	453.56	19.51	1409.09	141.30	321.88	480.58	621.88	300	158.70	3.03	0.44	319.64	160.94
15.06	456.14	19.82	1414.43	140.96	322.49	481.53	622.49	300	159.04	3.03	0.44	320.29	161.24
15.25	457.14	20.07	1418.88	140.61	322.18	481.58	622.18	300	159.39	3.02	0.44	320.49	161.09
15.48	459.85	20.37	1424.23	140.35	322.88	482.53	622.88	300	159.65	3.02	0.43	321.09	161.44
15.67	460.79	20.62	1428.66	141.41	322.53	481.12	622.53	300	158.59	3.03	0.44	319.86	161.27
15.86	461.37	20.86	1433.13	140.87	321.93	481.06	621.93	300	159.13	3.02	0.44	320.10	160.97
16.05	463.86	21.12	1437.70	138.87	322.64	483.78	622.64	300	161.13	3.00	0.43	322.46	161.32
16.27	466.96	21.40	1442.99	140.26	323.61	483.34	623.61	300	159.74	3.03	0.43	321.54	161.80
16.48	467.33	21.68	1448.06	138.84	322.73	483.89	622.73	300	161.16	3.00	0.43	322.52	161.36
16.67	468.86	21.93	1452.67	138.81	322.75	483.94	622.75	300	161.19	3.00	0.43	322.56	161.38
16.91	471.66	22.25	1458.69	137.78	323.34	485.57	623.34	300	162.22	2.99	0.43	323.89	161.67
17.11	471.57	22.52	1463.75	137.08	322.17	485.08	622.17	300	162.92	2.98	0.43	324.00	161.08
17.33	472.77	22.81	1469.21	136.53	321.79	485.26	621.79	300	163.47	2.97	0.42	324.37	160.89
17.52	473.98	23.05	1473.91	135.99	321.58	485.58	621.58	300	164.01	2.96	0.42	324.80	160.79

17.75	475.87	23.35	1479.63	135.35	321.61	486.26	621.61	300	164.65	2.95	0.42	325.45	160.81
17.92	477.68	23.58	1484.11	134.71	321.86	487.15	621.86	300	165.29	2.95	0.42	326.22	160.93
18.12	475.69	23.84	1489.27	134.07	319.41	485.35	619.41	300	165.93	2.92	0.42	325.64	159.71
18.32	476.87	24.11	1494.46	133.27	319.10	485.83	619.10	300	166.73	2.91	0.42	326.28	159.55
18.52	478.10	24.37	1499.55	132.89	318.83	485.94	618.83	300	167.11	2.91	0.42	326.52	159.41
18.54	476.11	24.39	1500.13	132.63	317.38	484.75	617.38	300	167.37	2.90	0.42	326.06	158.69
18.75	474.72	24.67	1505.68	132.35	315.29	482.93	615.29	300	167.65	2.88	0.42	325.29	157.64
18.93	477.91	24.91	1510.38	131.82	316.42	484.60	616.42	300	168.18	2.88	0.42	326.39	158.21
19.13	481.69	25.17	1515.61	131.34	317.82	486.48	617.82	300	168.66	2.88	0.41	327.57	158.91
19.33	484.88	25.44	1521.15	130.96	318.76	487.79	618.76	300	169.04	2.89	0.41	328.42	159.38

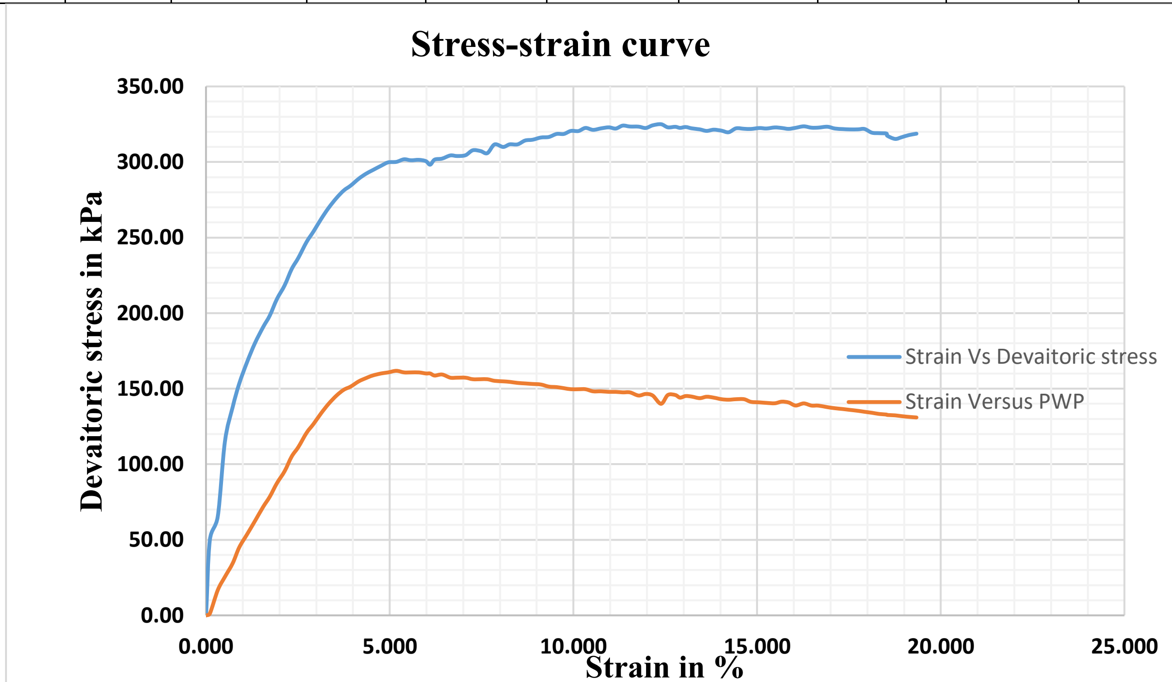


Fig C.11- Stress-strain Curve for effective consolidation pressure of 300 kPa and strain rate of 0.01mm/min

Table C8. Compression stage result for 400 kPa effective consolidation pressure													
Location		Asela kebele 09 (chigign mefelfeya area)					Job reference			thesis research			
Soil Description		red brown clay					Pit number			1			
Test method		CU with measurement of pore wate pressure; BS 1377: clause 8					Sample no			1			
							Depth			3.00m			
Area mm2	1134.115	strain rate in mm/min			0.01		Effective stress			400			
Axial	Change in	Axial	Area	Change in	Deviator	Principle stresses					Coefficient	Stress path parameters	
Disp. (mm)	Force (N)	Strain (%)	corrected (mm²)	pore pr. (kPa)	stress (kPa)	Major (σ₁') (kPa)	major(σ1) (kpa)	minor (σ3) Kpa	Minor (σ₃') (kPa)	σ₁'/σ₃' (-)'	A (-)	s' (kPa)	T (kPa)
0.000	0.00	0.00	1134.11	0.00	0.00	400.00	400.00	400	400.00	1.00	-	400.00	0.00
0.103	38.50	0.14	1135.65	11.78	33.90	422.12	433.90	400	388.22	1.09	0.35	405.17	16.95
0.303	82.70	0.40	1138.65	22.48	72.63	450.15	472.63	400	377.52	1.19	0.31	413.83	36.31
0.510	114.63	0.67	1141.78	34.91	100.40	465.49	500.40	400	365.09	1.27	0.35	415.29	50.20
0.722	148.80	0.95	1144.99	53.28	129.96	476.68	529.96	400	346.72	1.37	0.41	411.70	64.98
0.922	174.27	1.21	1148.04	73.82	151.80	477.98	551.80	400	326.18	1.47	0.49	402.08	75.90
1.130	199.97	1.49	1151.23	85.84	173.70	487.86	573.70	400	314.16	1.55	0.49	401.01	86.85
1.325	228.46	1.74	1154.24	103.02	197.93	494.91	597.93	400	296.98	1.67	0.52	395.94	98.97
1.528	243.47	2.01	1157.38	116.97	210.36	493.39	610.36	400	283.03	1.74	0.56	388.21	105.18
1.730	255.84	2.28	1160.53	127.72	220.45	492.74	620.45	400	272.28	1.81	0.58	382.51	110.23
1.934	257.60	2.54	1163.73	137.82	221.36	483.54	621.36	400	262.18	1.84	0.62	372.86	110.68
2.037	270.61	2.68	1165.35	144.47	232.21	487.74	632.21	400	255.53	1.91	0.62	371.64	116.11
2.238	283.42	2.94	1168.52	153.93	242.55	488.62	642.55	400	246.07	1.99	0.63	367.34	121.27
2.448	291.99	3.22	1171.86	162.11	249.17	487.06	649.17	400	237.89	2.05	0.65	362.48	124.58
2.768	305.10	3.64	1176.98	173.72	259.22	485.51	659.22	400	226.28	2.15	0.67	355.90	129.61
2.965	319.50	3.90	1180.16	183.17	270.73	487.55	670.73	400	216.83	2.25	0.68	352.19	135.36
3.164	333.94	4.16	1183.38	189.20	282.19	492.99	682.19	400	210.80	2.34	0.67	351.90	141.10
3.354	346.95	4.41	1186.48	194.44	292.42	497.99	692.42	400	205.56	2.42	0.66	351.77	146.21
3.541	358.56	4.66	1189.54	198.36	301.43	503.06	701.43	400	201.64	2.49	0.66	352.35	150.71
3.737	365.71	4.92	1192.76	202.04	306.61	504.57	706.61	400	197.96	2.55	0.66	351.27	153.30
3.940	371.42	5.18	1196.12	205.18	310.52	505.34	710.52	400	194.82	2.59	0.66	350.08	155.26
4.149	377.84	5.46	1199.60	206.76	314.97	508.22	714.97	400	193.24	2.63	0.66	350.73	157.49

4.356	391.35	5.73	1203.07	208.59	325.29	516.71	725.29	400	191.41	2.70	0.64	354.06	162.65
4.556	395.62	5.99	1206.44	210.16	327.92	517.76	727.92	400	189.84	2.73	0.64	353.80	163.96
4.740	398.49	6.24	1209.55	211.73	329.45	517.72	729.45	400	188.27	2.75	0.64	352.99	164.73
4.943	406.35	6.50	1213.01	213.04	334.99	521.95	734.99	400	186.96	2.79	0.64	354.46	167.50
5.150	411.34	6.78	1216.55	214.87	338.12	523.25	738.12	400	185.13	2.83	0.64	354.19	169.06
5.358	414.20	7.05	1220.13	215.40	339.47	524.08	739.47	400	184.60	2.84	0.63	354.34	169.74
5.563	421.60	7.32	1223.69	215.66	344.53	528.87	744.53	400	184.34	2.87	0.63	356.60	172.27
5.783	426.10	7.61	1227.52	217.49	347.12	529.63	747.12	400	182.51	2.90	0.63	356.07	173.56
5.990	428.76	7.88	1231.15	217.49	348.26	530.77	748.26	400	182.51	2.91	0.62	356.64	174.13
6.112	433.60	8.04	1233.30	217.76	351.58	533.82	751.58	400	182.24	2.93	0.62	358.03	175.79
6.320	436.24	8.32	1236.98	218.54	352.67	534.12	752.67	400	181.46	2.94	0.62	357.79	176.33
6.523	441.21	8.58	1240.59	218.54	355.64	537.10	755.64	400	181.46	2.96	0.61	359.28	177.82
6.706	444.22	8.82	1243.87	217.76	357.13	539.37	757.13	400	182.24	2.96	0.61	360.80	178.56
6.905	448.28	9.09	1247.45	217.24	359.36	542.12	759.36	400	182.76	2.97	0.60	362.44	179.68
7.114	451.02	9.36	1251.24	215.92	360.46	544.54	760.46	400	184.08	2.96	0.60	364.31	180.23
7.321	456.12	9.63	1255.01	215.66	363.44	547.78	763.44	400	184.34	2.97	0.59	366.06	181.72
7.538	458.95	9.92	1258.99	214.09	364.54	550.45	764.54	400	185.91	2.96	0.59	368.18	182.27
7.740	461.71	10.18	1262.71	211.99	365.65	553.66	765.65	400	188.01	2.94	0.58	370.83	182.82
7.940	464.47	10.45	1266.42	211.73	366.76	555.02	766.76	400	188.27	2.95	0.58	371.65	183.38
8.114	468.02	10.68	1269.67	209.89	368.62	558.72	768.62	400	190.11	2.94	0.57	374.41	184.31
8.309	472.70	10.93	1273.33	209.11	371.23	562.12	771.23	400	190.89	2.94	0.56	376.51	185.62
8.696	475.90	11.44	1280.65	207.01	371.61	564.60	771.61	400	192.99	2.93	0.56	378.79	185.80
8.904	477.31	11.72	1284.62	205.54	371.56	566.02	771.56	400	194.46	2.91	0.55	380.24	185.78
9.009	479.97	11.85	1286.63	204.25	373.04	568.79	773.04	400	195.75	2.91	0.55	382.27	186.52
9.216	483.86	12.13	1290.62	204.04	374.91	570.87	774.91	400	195.96	2.91	0.54	383.42	187.45
9.426	485.40	12.40	1294.69	202.30	374.92	572.61	774.92	400	197.70	2.90	0.54	385.16	187.46
9.619	488.71	12.66	1298.45	200.73	376.38	575.65	776.38	400	199.27	2.89	0.53	387.46	188.19
9.814	492.08	12.91	1302.28	199.52	377.86	578.34	777.86	400	200.48	2.88	0.53	389.41	188.93
10.03	494.13	13.19	1306.45	199.08	378.22	579.14	778.22	400	200.92	2.88	0.53	390.03	189.11
10.23	499.60	13.46	1310.58	197.58	381.21	583.62	781.21	400	202.42	2.88	0.52	393.02	190.60
10.44	499.71	13.74	1314.78	197.58	380.07	582.49	780.07	400	202.42	2.88	0.52	392.45	190.04
10.66	504.28	14.02	1319.06	196.08	382.30	586.22	782.30	400	203.92	2.87	0.51	395.07	191.15
10.87	508.38	14.30	1323.35	195.86	384.16	588.30	784.16	400	204.14	2.88	0.51	396.22	192.08
11.08	511.06	14.58	1327.76	195.64	384.90	589.26	784.90	400	204.36	2.88	0.51	396.81	192.45
11.29	515.19	14.86	1332.07	193.01	386.76	593.75	786.76	400	206.99	2.87	0.50	400.37	193.38

11.5	516.30	15.13	1336.24	193.28	386.38	593.10	786.38	400	206.72	2.87	0.50	399.91	193.19
11.6	516.61	15.26	1338.35	192.42	386.00	593.59	786.00	400	207.58	2.86	0.50	400.58	193.00
11.80	521.27	15.53	1342.65	191.34	388.24	596.90	788.24	400	208.66	2.86	0.49	402.78	194.12
12.00	523.36	15.79	1346.78	189.92	388.60	598.68	788.60	400	210.08	2.85	0.49	404.38	194.30
12.21	527.08	16.07	1351.20	189.92	390.08	600.16	790.08	400	210.08	2.86	0.49	405.12	195.04
12.43	528.85	16.35	1355.76	188.89	390.08	601.19	790.08	400	211.11	2.85	0.48	406.15	195.04
12.63	530.54	16.62	1360.13	187.65	390.07	602.41	790.07	400	212.35	2.84	0.48	407.38	195.03
12.83	533.73	16.88	1364.41	187.15	391.18	604.03	791.18	400	212.85	2.84	0.48	408.44	195.59
13.02	538.13	17.13	1368.49	185.35	393.23	607.88	793.23	400	214.65	2.83	0.47	411.26	196.62
13.20	538.55	17.37	1372.56	184.59	392.37	607.78	792.37	400	215.41	2.82	0.47	411.60	196.18
13.49	543.36	17.75	1378.80	184.05	394.08	610.03	794.08	400	215.95	2.82	0.47	412.99	197.04
13.69	545.09	18.01	1383.22	183.05	394.07	611.02	794.07	400	216.95	2.82	0.46	413.99	197.04
13.85	546.12	18.23	1386.89	181.25	393.77	612.52	793.77	400	218.75	2.80	0.46	415.63	196.89
14.20	549.98	18.68	1394.70	180.23	394.33	614.10	794.33	400	219.77	2.79	0.46	416.94	197.17
14.32	552.69	18.84	1397.37	179.64	395.52	615.89	795.52	400	220.36	2.79	0.45	418.12	197.76
14.51	555.96	19.09	1401.76	179.90	396.62	616.72	796.62	400	220.10	2.80	0.45	418.41	198.31
14.79	557.32	19.47	1408.24	178.20	395.76	617.56	795.76	400	221.80	2.78	0.45	419.68	197.88
15.10	560.53	19.87	1415.39	177.72	396.03	618.31	796.03	400	222.28	2.78	0.45	420.30	198.01
15.32	563.71	20.15	1420.35	177.36	396.88	619.52	796.88	400	222.64	2.78	0.45	421.08	198.44
15.53	566.08	20.43	1425.31	176.23	397.16	620.93	797.16	400	223.77	2.77	0.44	422.35	198.58
15.75	569.39	20.72	1430.56	175.63	398.02	622.39	798.02	400	224.37	2.77	0.44	423.38	199.01
15.96	570.58	21.00	1435.64	175.51	397.44	621.93	797.44	400	224.49	2.77	0.44	423.21	198.72
16.17	573.84	21.28	1440.77	175.03	398.29	623.26	798.29	400	224.97	2.77	0.44	424.11	199.14
16.37	575.75	21.55	1445.58	175.24	398.28	623.04	798.28	400	224.76	2.77	0.44	423.90	199.14
16.57	578.12	21.80	1450.23	175.09	398.64	623.55	798.64	400	224.91	2.77	0.44	424.23	199.32
16.77	580.10	22.06	1455.15	174.07	398.65	624.58	798.65	400	225.93	2.76	0.44	425.26	199.33
16.97	581.93	22.33	1460.25	174.37	398.51	624.14	798.51	400	225.63	2.77	0.44	424.88	199.26
17.18	583.96	22.61	1465.49	174.61	398.47	623.86	798.47	400	225.39	2.77	0.44	424.62	199.24
17.39	584.78	22.89	1470.72	173.88	397.62	623.73	797.62	400	226.12	2.76	0.44	424.92	198.81
17.45	587.09	23.03	1473.35	172.94	398.47	625.53	798.47	400	227.06	2.75	0.43	426.29	199.24
17.70	588.31	23.30	1478.56	173.64	397.89	624.25	797.89	400	226.36	2.76	0.44	425.30	198.95
17.90	590.31	23.56	1483.60	172.43	397.89	625.46	797.89	400	227.57	2.75	0.43	426.52	198.95
18.10	592.42	23.81	1488.52	172.43	397.99	625.57	797.99	400	227.57	2.75	0.43	426.57	199.00
18.29	594.71	24.07	1493.58	171.92	398.18	626.26	798.18	400	228.08	2.75	0.43	427.17	199.09
18.48	594.06	24.31	1498.46	172.17	396.45	624.28	796.45	400	227.83	2.74	0.43	426.06	198.22

18.68	598.73	24.58	1503.69	172.20	398.18	625.98	798.18	400	227.80	2.75	0.43	426.89	199.09
18.88	599.94	24.84	1508.92	171.24	397.59	626.36	797.59	400	228.76	2.74	0.43	427.56	198.80
19.08	602.40	25.11	1514.38	171.72	397.79	626.07	797.79	400	228.28	2.74	0.43	427.18	198.89
19.29	605.65	25.39	1519.99	170.03	398.46	628.43	798.46	400	229.97	2.73	0.43	429.20	199.23
19.50	607.38	25.65	1525.45	169.78	398.16	628.39	798.16	400	230.22	2.73	0.43	429.30	199.08
19.70	609.12	25.92	1530.95	168.33	397.87	629.54	797.87	400	231.67	2.72	0.42	430.61	198.93
19.90	611.69	26.18	1536.41	169.14	398.13	628.99	798.13	400	230.86	2.72	0.42	429.93	199.06
20.09	614.29	26.44	1541.72	169.30	398.45	629.15	798.45	400	230.70	2.73	0.42	429.92	199.22
20.30	615.65	26.71	1547.36	168.09	397.87	629.78	797.87	400	231.91	2.72	0.42	430.85	198.94
20.51	617.62	26.99	1553.41	168.09	397.59	629.50	797.59	400	231.91	2.71	0.42	430.71	198.79
20.73	619.58	27.28	1559.49	166.64	397.30	630.66	797.30	400	233.36	2.70	0.42	432.01	198.65
20.95	618.83	27.56	1565.69	167.31	395.24	627.94	795.24	400	232.69	2.70	0.42	430.32	197.62

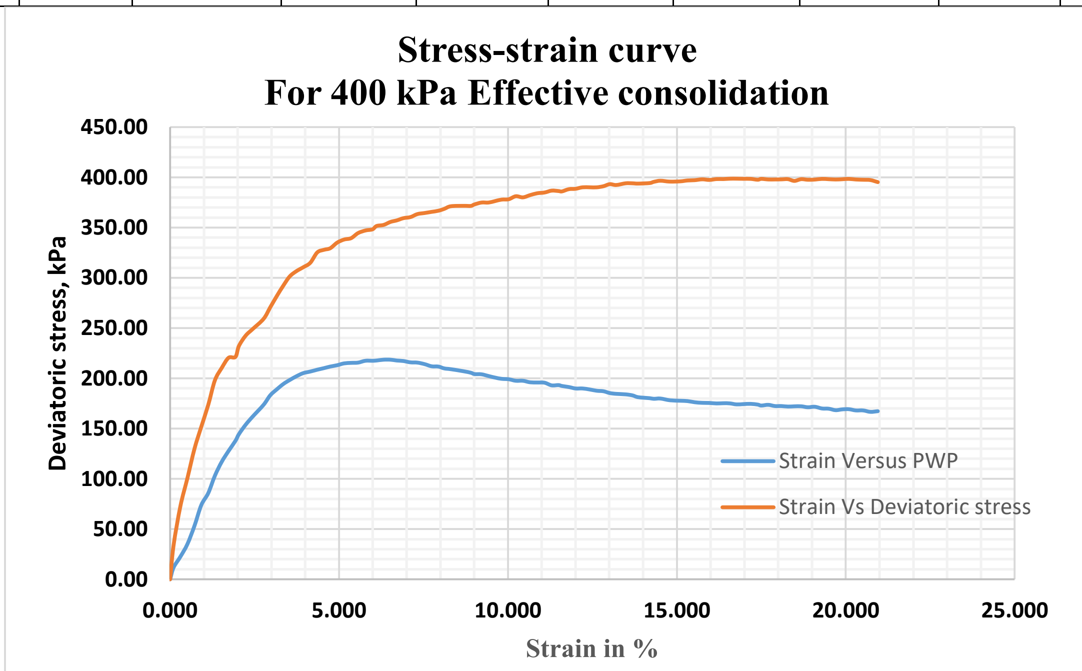


Fig.C.12. Stress-strain curves for Effective consolidation pressure of 400 kPa and strain rate of 0.01mm/min

1.3) Triaxial compression test result for strain rate 0.1mm/min

Table C9: consolidation Stage result for effective consolidation pressure of 200kPa, 300kPa and 400kPa

Location: Asela kebele 09 (chigign mefelfeya)						Job reference		Thesis research
Soil Description: Red brown Clay						pit No		#1
Test Method: CU with pore water pressure measurement, BS 1377,clause 8						sample No		#1
						Depth		2.8m
Remolded soil								
Effective consolidation pressure of 200 kPa			Effective consolidation pressure of 300 kPa			Effective consolidation pressure of 400 kPa		
Initial condition	CP,kPa	500	Initial condition	CP,kPa	600	Initial condition	CP,kPa	700
	BP,kPa	300		BP,kPa	300		BP,kPa	300
	PP,kPa	312.83		PP,kPa	580.42		PP,kPa	664.18
Final condition	PP,kPpa	118.91	Final condition	PP,kPa	264.52	Final condition	PP,kPa	290.65
	Δvolume,	4.42		Δvolum	4.98		Δvolume	6.20
	%consolidation	98.4		%consolidation	99.60		%consolidation	100.00
Sqrt of time	Δvolume, mm	PP,kPa	Sqrt of time	Δvolume,mm	PP,kPa	Sqrt of time	Δvolume ,mm	PP,kPa
0.29	4.51	329.85	0.00	5.09	580.419	0.300	6.18	664.18
0.36	4.45	329.01	0.36	5.29	580.419	0.370	6.19	664.09
0.44	4.02	119.46	0.44	4.66	286.396	0.460	5.23	292.78
0.54	3.97	119.18	0.54	4.62	285.862	0.560	5.13	292.07
0.66	3.89	119.00	0.66	4.62	285.513	0.690	5.07	291.71
0.81	3.80	118.83	0.81	4.57	285.154	0.830	5.01	291.45
1.00	3.73	118.73	1.00	4.54	285.062	1.030	4.96	291.27
1.22	3.65	118.64	1.22	4.42	284.979	1.260	4.90	291.10
1.49	3.58	118.55	1.49	4.38	284.804	1.540	4.82	290.91
1.83	3.50	118.46	1.83	4.22	284.620	1.890	4.65	290.65
2.24	3.45	118.28	2.24	4.02	284.620	2.320	4.51	290.47
2.74	3.32	118.19	2.74	3.86	284.446	2.840	4.38	290.47
3.36	3.05	118.36	3.36	3.67	284.354	3.470	4.23	290.30
4.11	3.00	118.28	4.11	3.51	284.446	4.250	4.05	290.20
5.04	2.74	119.30	5.04	3.23	284.446	5.210	3.77	290.20
6.17	2.48	118.83	6.17	2.88	284.538	6.380	3.45	290.30
7.56	2.09	118.55	7.56	2.52	284.712	7.820	2.95	290.39
9.26	1.79	118.73	9.26	2.05	284.887	9.570	2.58	290.39
11.34	1.33	118.73	11.34	1.61	285.062	11.720	1.91	290.65
13.89	0.96	119.18	13.89	1.18	285.329	14.360	1.44	291.20
17.01	0.68	119.00	17.01	0.63	286.221	17.590	1.02	290.47
20.83	0.32	119.63	20.83	0.23	285.954	21.540	0.50	291.27
25.51	0.16	119.46	25.51	0.17	285.954	26.380	0.14	291.10
31.25	0.09	118.91	31.25	0.11	285.780	32.310	0.00	290.65

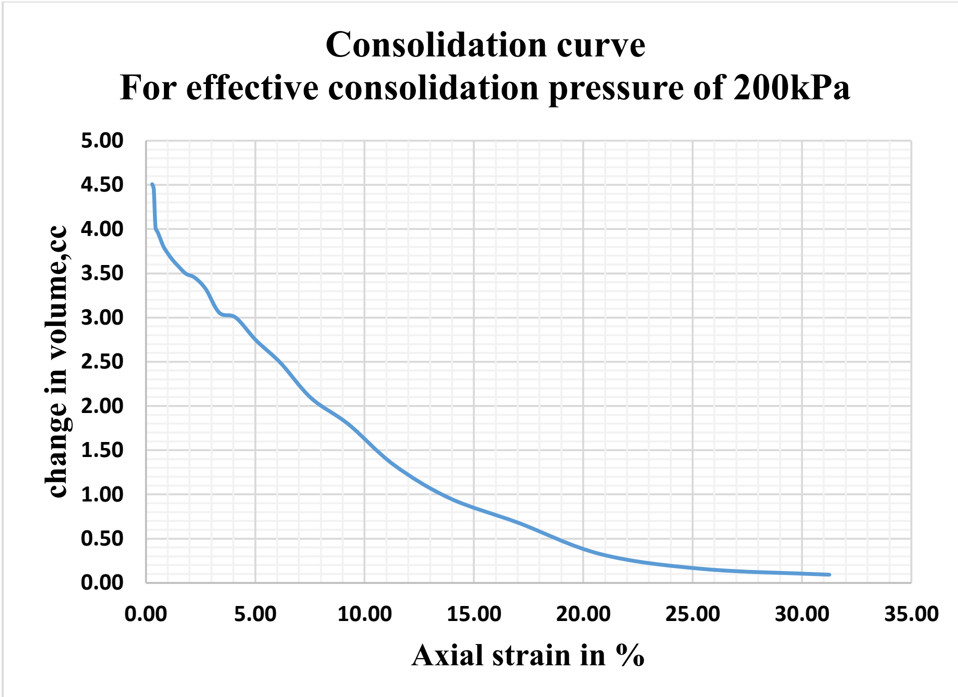


Fig C.13. Consolidation curve for effective consolidation pressure of 200 kPa

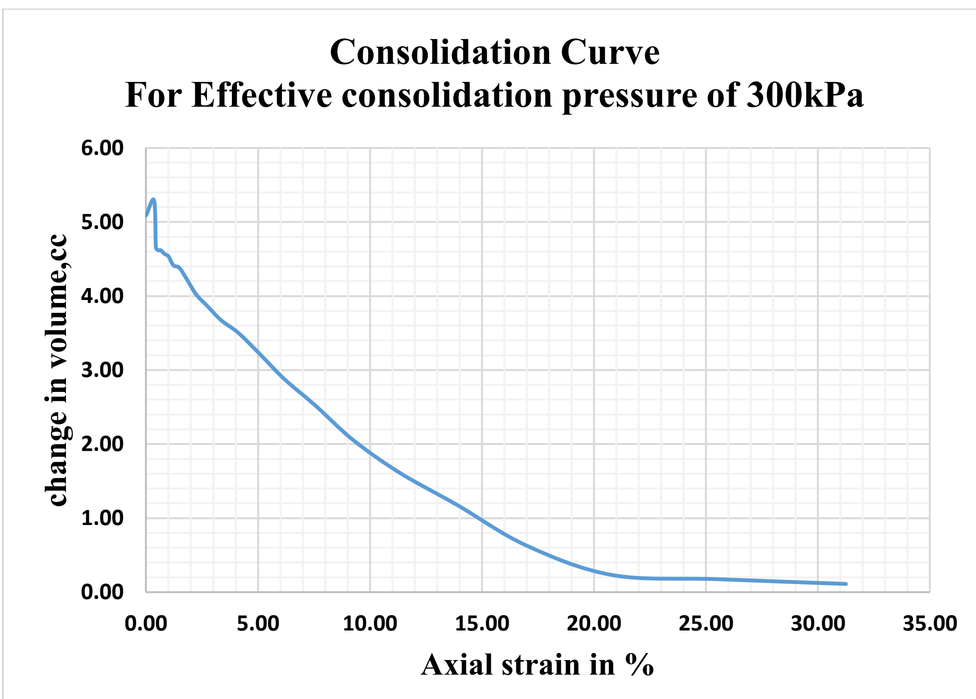


Fig C.14. Consolidation curve for effective consolidation pressure of 300 kPa

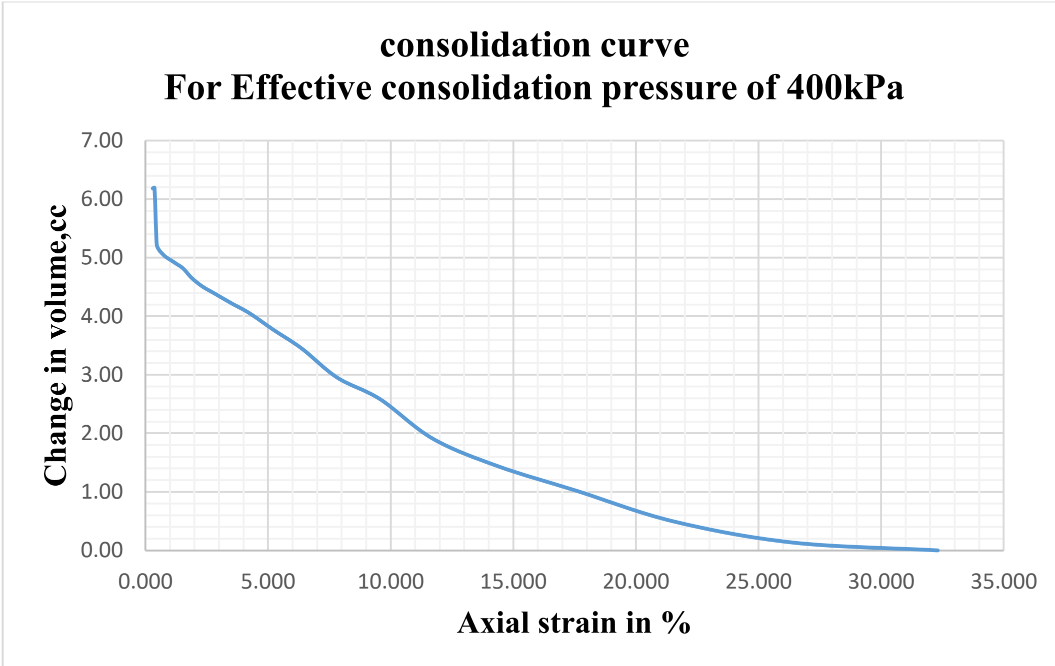


Fig C.15. Consolidation curve for effective consolidation pressure of 400 kPa

Table C10. Compression stage result for 200 kPa effective consolidation pressure			
Location	**Asela kebele 09 (chigign mefelfeya area**	**Job reference**	**thesis research**
soil Description	**red brown clay**	**Pit number**	**1**
Test method	**CU with measurement of pore water pressure; BS 1377: clause 8**	**sample no**	**1**
		depth	**3.00m**
Area in mm2 1134.11	**strain rate(mm/min)** 0.10	Effective stress	**200**

Axial Disp. (mm)	Change in force (N)	Axial Strain (%)	Area corrected (mm^2)	Change in pore pr. (kPa)	Deviator stress (kPa)	Principle stresses: Major (σ_1') (kPa)	major(σ1) (kPa)	minor (σ3) kPa	Minor (σ_3') (kPa)	σ_1'/σ_3' (-)'	Coefficient A (-)	Stress path parameters: s' (kPa)	T (kPa)
0.00	0.00	0.00	1134.11	0.00	0.00	200.00	200.00	200	200.00	1.00	-	200.00	0.00
0.16	5.50	0.21	1136.51	1.53	4.84	203.31	204.84	200	198.47	1.02	0.32	200.89	2.42
0.35	60.60	0.46	1139.36	5.12	53.19	248.07	253.19	200	194.88	1.27	0.10	221.47	26.59
0.54	117.90	0.71	1142.23	8.90	103.22	294.32	303.22	200	191.10	1.54	0.09	242.71	51.61
0.74	145.30	0.97	1145.27	11.78	126.87	315.09	326.87	200	188.22	1.67	0.09	251.66	63.44
0.92	159.40	1.21	1148.01	14.32	138.85	324.53	338.85	200	185.68	1.75	0.10	255.10	69.42
1.12	169.30	1.47	1151.08	19.42	147.08	327.66	347.08	200	180.58	1.81	0.13	254.12	73.54
1.33	184.40	1.75	1154.32	24.05	159.75	335.70	359.75	200	175.95	1.91	0.15	255.83	79.87
1.55	196.20	2.04	1157.73	28.67	169.47	340.80	369.47	200	171.33	1.99	0.17	256.06	84.74
1.76	210.00	2.32	1161.00	35.38	180.88	345.49	380.88	200	164.62	2.10	0.20	255.06	90.44
1.97	221.80	2.59	1164.29	39.32	190.50	351.18	390.50	200	160.68	2.19	0.21	255.93	95.25
2.18	232.40	2.87	1167.61	44.65	199.04	354.39	399.04	200	155.35	2.28	0.22	254.87	99.52
2.37	239.20	3.12	1170.62	48.58	204.34	355.75	404.34	200	151.42	2.35	0.24	253.58	102.17
2.56	249.20	3.37	1173.65	52.98	212.33	359.35	412.33	200	147.02	2.44	0.25	253.19	106.16
2.78	259.00	3.66	1177.17	56.97	220.02	363.05	420.02	200	143.03	2.54	0.26	253.04	110.01
2.98	268.16	3.92	1180.40	60.19	227.18	366.99	427.18	200	139.81	2.62	0.26	253.40	113.59
3.19	275.64	4.20	1183.80	60.73	232.84	372.11	432.84	200	139.27	2.67	0.26	255.69	116.42
3.40	281.23	4.47	1187.23	63.95	236.88	372.93	436.88	200	136.05	2.74	0.27	254.49	118.44
3.61	287.95	4.75	1190.67	65.48	241.84	376.36	441.84	200	134.52	2.80	0.27	255.44	120.92
3.82	294.42	5.03	1194.14	67.79	246.55	378.76	446.55	200	132.21	2.86	0.27	255.49	123.28
4.01	299.75	5.28	1197.29	68.72	250.36	381.64	450.36	200	131.28	2.91	0.27	256.46	125.18
4.19	305.06	5.51	1200.29	71.50	254.16	382.66	454.16	200	128.50	2.98	0.28	255.58	127.08
4.38	310.11	5.76	1203.47	72.19	257.68	385.49	457.68	200	127.81	3.02	0.28	256.65	128.84

4.57	311.52	6.01	1206.67	73.34	258.16	384.82	458.16	200	126.66	3.04	0.28	255.74	129.08
4.77	315.26	6.28	1210.06	75.43	260.53	385.10	460.53	200	124.57	3.09	0.29	254.83	130.27
4.98	318.78	6.55	1213.64	75.90	262.66	386.77	462.66	200	124.10	3.12	0.29	255.44	131.33
5.18	323.74	6.82	1217.07	77.74	266.00	388.26	466.00	200	122.26	3.18	0.29	255.26	133.00
5.38	324.94	7.08	1220.51	78.21	266.23	388.02	466.23	200	121.79	3.19	0.29	254.91	133.12
5.57	328.18	7.33	1223.81	79.60	268.16	388.56	468.16	200	120.40	3.23	0.30	254.48	134.08
5.77	332.34	7.59	1227.29	80.29	272.29	392.00	472.29	200	119.71	3.27	0.29	255.86	136.15
5.98	334.18	7.87	1230.97	81.45	272.51	391.06	472.51	200	118.55	3.30	0.30	254.81	136.25
6.18	335.45	8.13	1234.50	81.68	274.94	393.26	474.94	200	118.32	3.32	0.30	255.79	137.47
6.40	339.41	8.42	1238.40	82.14	274.72	392.57	474.72	200	117.86	3.33	0.30	255.21	137.36
6.62	340.21	8.71	1242.33	82.14	276.85	394.71	476.85	200	117.86	3.35	0.30	256.28	138.43
6.83	343.94	8.99	1246.10	82.61	278.52	395.91	478.52	200	117.39	3.37	0.30	256.65	139.26
7.04	347.06	9.26	1249.89	82.84	281.79	398.95	481.79	200	117.16	3.41	0.29	258.06	140.90
7.24	352.21	9.53	1253.53	82.61	280.14	397.53	480.14	200	117.39	3.39	0.29	257.46	140.07
7.43	351.16	9.78	1257.00	82.38	280.89	398.51	480.89	200	117.62	3.39	0.29	258.07	140.45
7.63	353.08	10.04	1260.68	83.30	283.07	399.77	483.07	200	116.70	3.43	0.29	258.24	141.53
7.84	356.86	10.32	1264.56	83.30	283.96	400.67	483.96	200	116.70	3.43	0.29	258.69	141.98
8.03	359.09	10.57	1268.10	82.61	284.80	402.19	484.80	200	117.39	3.43	0.29	259.79	142.40
8.25	361.15	10.86	1272.22	82.84	285.72	402.88	485.72	200	117.16	3.44	0.29	260.02	142.86
8.46	363.50	11.13	1276.17	82.38	287.37	404.99	487.37	200	117.62	3.44	0.29	261.31	143.68
8.66	366.73	11.39	1279.96	82.38	287.58	405.20	487.58	200	117.62	3.44	0.29	261.41	143.79
8.85	368.09	11.64	1283.59	82.14	290.21	408.07	490.21	200	117.86	3.46	0.28	262.96	145.11
9.04	372.51	11.89	1287.23	81.68	289.72	408.04	489.72	200	118.32	3.45	0.28	263.18	144.86
9.23	372.94	12.14	1290.89	81.68	288.90	407.22	488.90	200	118.32	3.44	0.28	262.77	144.45
9.41	376.13	12.38	1294.38	81.22	290.59	409.37	490.59	200	118.78	3.45	0.28	264.08	145.29
9.61	378.16	12.64	1298.28	82.11	291.28	409.17	491.28	200	117.89	3.47	0.28	263.53	145.64
9.82	378.77	12.92	1302.40	80.92	290.82	409.90	490.82	200	119.08	3.44	0.28	264.49	145.41
10.0	382.11	13.18	1306.35	80.92	292.50	411.58	492.50	200	119.08	3.46	0.28	265.33	146.25
10.23	384.28	13.46	1310.52	81.31	293.23	411.92	493.23	200	118.69	3.47	0.28	265.30	146.61
10.43	383.00	13.72	1314.51	80.12	291.36	411.24	491.36	200	119.88	3.43	0.27	265.56	145.68
10.64	388.89	14.00	1318.74	80.32	294.90	414.58	494.90	200	119.68	3.46	0.27	267.13	147.45
10.84	388.86	14.26	1322.79	80.32	293.97	413.65	493.97	200	119.68	3.46	0.27	266.67	146.99
11.03	391.63	14.51	1326.65	80.72	295.20	414.48	495.20	200	119.28	3.47	0.27	266.88	147.60
11.24	393.73	14.79	1330.96	79.92	295.82	415.90	495.82	200	120.08	3.46	0.27	267.99	147.91
11.46	398.28	15.08	1335.49	79.33	298.23	418.90	498.23	200	120.67	3.47	0.27	269.79	149.11

11.68	401.51	15.37	1340.06	78.62	299.62	421.00	499.62	200	121.38	3.47	0.26	271.19	149.81
11.90	399.88	15.66	1344.66	78.93	297.38	418.46	497.38	200	121.07	3.46	0.27	269.76	148.69
12.11	403.51	15.93	1349.08	78.53	299.10	420.57	499.10	200	121.47	3.46	0.26	271.02	149.55
12.30	406.37	16.18	1353.10	78.14	300.32	422.19	500.32	200	121.86	3.46	0.26	272.03	150.16
12.52	408.33	16.47	1357.79	78.34	300.73	422.39	500.73	200	121.66	3.47	0.26	272.03	150.37
12.71	409.04	16.72	1361.87	77.54	300.35	422.82	500.35	200	122.46	3.45	0.26	272.64	150.18
12.91	408.51	16.99	1366.19	77.74	299.01	421.28	499.01	200	122.26	3.45	0.26	271.77	149.51
13.12	411.14	17.26	1370.75	77.34	299.94	422.60	499.94	200	122.66	3.45	0.26	272.63	149.97
13.33	412.85	17.54	1375.34	78.14	300.18	422.04	500.18	200	121.86	3.46	0.26	271.95	150.09
13.53	412.82	17.80	1379.75	77.34	299.20	421.86	499.20	200	122.66	3.44	0.26	272.26	149.60
13.74	416.69	18.08	1384.40	76.14	300.99	424.85	500.99	200	123.86	3.43	0.25	274.35	150.49
13.93	416.33	18.33	1388.64	75.94	299.81	423.87	499.81	200	124.06	3.42	0.25	273.96	149.91
14.11	416.60	18.57	1392.68	76.74	299.14	422.39	499.14	200	123.26	3.43	0.26	272.82	149.57
14.30	420.66	18.82	1396.96	77.14	301.12	423.99	501.12	200	122.86	3.45	0.26	273.43	150.56
14.48	422.79	19.05	1401.05	75.55	301.77	426.21	501.77	200	124.45	3.42	0.25	275.33	150.88
14.69	422.56	19.33	1405.85	76.14	300.57	424.43	500.57	200	123.86	3.43	0.25	274.14	150.29
14.90	426.73	19.61	1410.68	75.74	302.50	426.75	502.50	200	124.26	3.43	0.25	275.51	151.25
15.10	427.14	19.87	1415.32	76.14	301.80	425.65	501.80	200	123.86	3.44	0.25	274.76	150.90
15.31	427.14	20.14	1420.21	75.35	300.76	425.41	500.76	200	124.65	3.41	0.25	275.03	150.38
15.51	430.98	20.41	1424.91	75.55	302.46	426.91	502.46	200	124.45	3.43	0.25	275.68	151.23
15.70	432.19	20.66	1429.40	74.95	302.36	427.41	502.36	200	125.05	3.42	0.25	276.23	151.18
15.90	431.74	20.92	1434.16	74.92	301.04	426.12	501.04	200	125.08	3.41	0.25	275.60	150.52
16.11	434.70	21.20	1439.18	75.39	302.05	426.65	502.05	200	124.61	3.42	0.25	275.63	151.02
16.33	437.40	21.49	1444.49	75.35	302.81	427.45	502.81	200	124.65	3.43	0.25	276.05	151.40
16.54	437.63	21.76	1449.59	75.75	301.90	426.15	501.90	200	124.25	3.43	0.25	275.20	150.95
16.76	441.56	22.05	1454.98	75.94	303.48	427.54	503.48	200	124.06	3.45	0.25	275.80	151.74
16.98	442.33	22.34	1460.40	75.36	302.88	427.52	502.88	200	124.64	3.43	0.25	276.08	151.44
17.18	444.14	22.61	1465.36	73.76	303.09	429.33	503.09	200	126.24	3.40	0.24	277.79	151.55
17.37	442.33	22.86	1470.11	73.77	300.88	427.11	500.88	200	126.23	3.38	0.25	276.67	150.44
17.56	444.14	23.11	1474.89	73.57	301.13	427.57	501.13	200	126.43	3.38	0.24	277.00	150.57
17.77	443.99	23.38	1480.21	72.97	299.95	426.98	499.95	200	127.03	3.36	0.24	277.01	149.98
17.97	443.58	23.64	1485.31	72.17	298.64	426.48	498.64	200	127.83	3.34	0.24	277.15	149.32
18.18	444.74	23.92	1490.71	71.38	298.34	426.97	498.34	200	128.62	3.32	0.24	277.79	149.17
18.59	448.70	24.46	1501.35	71.38	298.86	427.49	498.86	200	128.62	3.32	0.24	278.06	149.43
18.78	450.96	24.71	1506.34	71.35	299.37	428.02	499.37	200	128.65	3.33	0.24	278.34	149.69

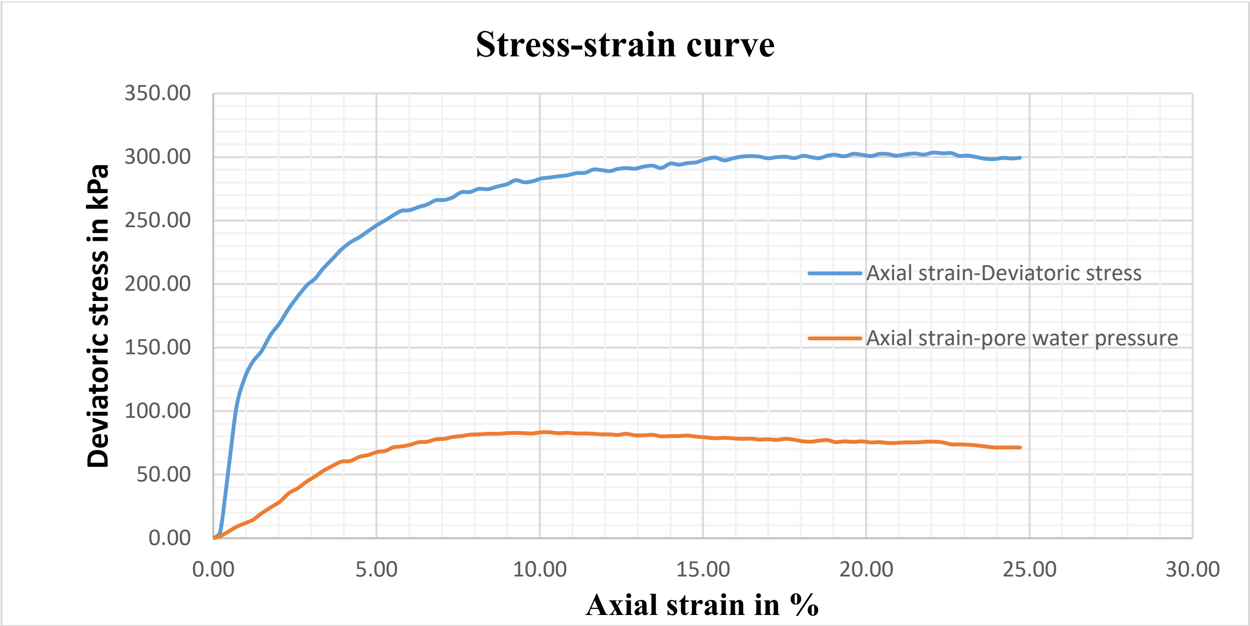


Fig C.16. Stress-strain curve for 200kPa effective consolidation pressure and strain rate of 0.1mm/min

Table C11. Compression stage result for 300 kPa effective consolidation pressure														
Location		Asela kebele 09 (chigign mefelfeya area						Job reference			thesis research			
soil Description		Red brown clay						Pit number			1			
Test method		CU with measurement of pore water pressure; BS 1377: clause 8						sample no			1			
								depth			3.00m			
Area in mm2		1134.11	strain rate(mm/min)			0.10		Effective stress (kPa)			300			
Axial Disp. (mm)	Change in force (N)	Axial strain (%)	Area corrected (mm²)	Change in pore pr. (kPa)	Deviator stress (kPa)	Principle stresses: Major (σ₁') (kPa)	major(σ1) (kPa)	minor (σ3) KPa	Minor (σ₃') (kPa)	σ₁'/σ₃' (-)'	Coefficient A (-)	Stress path parameters: s' (kPa)	T (kPa)	
0.00	0.00	0.00	1134.11	0.00	0.00	300.00	300.00	300	300.00	1.00	-	300.00	0.00	
0.14	18.61	0.18	1136.21	5.84	16.38	310.55	316.38	300	294.16	1.06	0.36	302.36	8.19	
0.34	33.93	0.45	1139.21	8.50	29.78	321.29	329.78	300	291.50	1.10	0.29	306.40	14.89	
0.50	63.80	0.66	1141.63	15.03	55.89	340.86	355.89	300	284.97	1.20	0.27	312.91	27.94	
0.74	117.23	0.97	1145.27	22.78	102.36	379.59	402.36	300	277.22	1.37	0.22	328.40	51.18	
0.94	135.76	1.24	1148.32	29.02	118.23	389.20	418.23	300	270.98	1.44	0.25	330.09	59.11	
1.12	156.21	1.47	1151.08	31.59	135.71	404.13	435.71	300	268.41	1.51	0.23	336.27	67.86	
1.32	169.44	1.74	1154.16	39.44	146.81	407.37	446.81	300	260.56	1.56	0.27	333.96	73.40	
1.54	200.68	2.03	1157.57	47.74	173.36	425.63	473.36	300	252.26	1.69	0.28	338.94	86.68	
1.75	220.67	2.30	1160.84	56.27	190.09	433.82	490.09	300	243.73	1.78	0.30	338.78	95.05	
1.91	240.34	2.51	1163.35	59.24	206.59	447.35	506.59	300	240.76	1.86	0.29	344.06	103.30	
2.11	259.08	2.78	1166.50	64.73	222.10	457.38	522.10	300	235.27	1.94	0.29	346.32	111.05	
2.30	282.13	3.03	1169.51	69.44	241.24	471.80	541.24	300	230.56	2.05	0.29	351.18	120.62	
2.53	290.32	3.33	1173.17	74.11	247.47	473.36	547.47	300	225.89	2.10	0.30	349.63	123.73	
2.75	301.35	3.62	1176.69	74.56	256.10	481.53	556.10	300	225.44	2.14	0.29	353.49	128.05	
2.91	310.62	3.83	1179.27	74.56	263.40	488.84	563.40	300	225.44	2.17	0.28	357.14	131.70	
3.17	320.69	4.17	1183.48	82.12	270.97	488.85	570.97	300	217.88	2.24	0.30	353.36	135.49	
3.34	331.35	4.39	1186.25	90.90	279.33	488.42	579.33	300	209.10	2.34	0.33	348.76	139.66	
3.55	340.41	4.67	1189.69	95.49	286.14	490.65	586.14	300	204.51	2.40	0.33	347.58	143.07	
3.73	346.64	4.91	1192.65	99.74	290.65	490.91	590.65	300	200.26	2.45	0.34	345.59	145.32	
3.93	352.74	5.17	1195.96	105.91	294.95	489.03	594.95	300	194.09	2.52	0.36	341.56	147.47	
4.15	357.25	5.46	1199.62	114.76	297.80	483.04	597.80	300	185.24	2.61	0.39	334.14	148.90	
4.31	360.97	5.67	1202.30	125.49	300.23	474.74	600.23	300	174.51	2.72	0.42	324.62	150.12	

4.53	365.27	5.96	1206.00	136.57	302.88	466.30	602.88	300	163.43	2.85	0.45	314.86	151.44
4.71	368.23	6.20	1209.04	144.40	304.57	460.17	604.57	300	155.60	2.96	0.47	307.88	152.28
4.94	370.44	6.50	1212.96	151.02	305.40	454.38	605.40	300	148.98	3.05	0.49	301.68	152.70
5.16	374.14	6.79	1216.72	155.83	307.50	451.68	607.50	300	144.17	3.13	0.51	297.92	153.75
5.31	376.66	6.99	1219.31	159.89	308.91	449.02	608.91	300	140.11	3.20	0.52	294.57	154.45
5.36	380.23	7.05	1220.17	163.20	311.62	448.43	611.62	300	136.80	3.28	0.52	292.61	155.81
5.43	381.08	7.14	1221.38	165.00	312.01	447.01	612.01	300	135.00	3.31	0.53	291.01	156.01
5.47	386.22	7.20	1222.07	166.21	316.03	449.83	616.03	300	133.79	3.36	0.53	291.81	158.02
5.54	387.63	7.29	1223.29	166.95	316.87	449.92	616.87	300	133.05	3.38	0.53	291.49	158.44
5.60	389.10	7.37	1224.33	166.95	317.81	450.86	617.81	300	133.05	3.39	0.53	291.95	158.90
5.66	394.94	7.45	1225.37	167.10	322.31	455.20	622.31	300	132.90	3.43	0.52	294.05	161.15
5.71	396.21	7.51	1226.24	166.95	323.11	456.16	623.11	300	133.05	3.43	0.52	294.60	161.55
5.76	401.25	7.58	1227.12	166.95	326.99	460.04	626.99	300	133.05	3.46	0.51	296.54	163.49
5.96	400.77	7.84	1230.62	166.51	325.66	459.15	625.66	300	133.49	3.44	0.51	296.32	162.83
6.16	406.97	8.11	1234.15	165.91	329.75	463.85	629.75	300	134.09	3.46	0.50	298.97	164.88
6.36	407.86	8.37	1237.69	164.85	329.54	464.69	629.54	300	135.15	3.44	0.50	299.92	164.77
6.56	412.58	8.63	1241.25	163.64	332.39	468.75	632.39	300	136.36	3.44	0.49	302.55	166.19
6.74	418.21	8.87	1244.48	162.90	336.05	473.15	636.05	300	137.10	3.45	0.48	305.13	168.02
6.93	421.19	9.12	1247.90	161.99	337.52	475.53	637.52	300	138.01	3.45	0.48	306.77	168.76
7.17	425.87	9.43	1252.26	161.69	340.08	478.39	640.08	300	138.31	3.46	0.48	308.35	170.04
7.34	427.81	9.66	1255.36	160.63	340.79	480.16	640.79	300	139.37	3.45	0.47	309.76	170.40
7.55	431.88	9.93	1259.21	160.04	342.98	482.93	642.98	300	139.96	3.45	0.47	311.45	171.49
7.75	432.97	10.20	1262.90	158.83	342.84	484.01	642.84	300	141.17	3.43	0.46	312.59	171.42
7.94	435.98	10.45	1266.42	158.38	344.26	485.88	644.26	300	141.62	3.43	0.46	313.75	172.13
8.15	440.75	10.72	1270.34	158.38	346.96	488.58	646.96	300	141.62	3.45	0.46	315.10	173.48
8.36	443.48	11.00	1274.29	157.77	348.02	490.26	648.02	300	142.23	3.45	0.45	316.24	174.01
8.56	446.52	11.26	1278.07	157.63	349.37	491.74	649.37	300	142.37	3.45	0.45	317.06	174.69
8.77	450.08	11.54	1282.06	156.88	351.06	494.18	651.06	300	143.12	3.45	0.45	318.65	175.53
9.05	450.00	11.91	1287.42	155.68	349.53	493.86	649.53	300	144.32	3.42	0.45	319.09	174.77
9.25	451.02	12.17	1291.28	155.07	349.28	494.21	649.28	300	144.93	3.41	0.44	319.57	174.64
9.46	452.32	12.45	1295.35	154.32	349.19	494.87	649.19	300	145.68	3.40	0.44	320.28	174.59
9.60	454.15	12.63	1298.08	153.72	349.86	496.14	649.86	300	146.28	3.39	0.44	321.21	174.93
9.81	454.64	12.91	1302.20	153.27	349.13	495.86	649.13	300	146.73	3.38	0.44	321.30	174.57
10.0	454.11	13.17	1306.15	152.82	347.67	494.85	647.67	300	147.18	3.36	0.44	321.02	173.84
10.22	455.77	13.45	1310.32	152.06	347.83	495.77	647.83	300	147.94	3.35	0.44	321.85	173.92

10.43	458.79	13.72	1314.51	151.61	349.02	497.40	649.02	300	148.39	3.35	0.43	322.90	174.51
10.63	462.52	13.99	1318.54	151.16	350.79	499.63	650.79	300	148.84	3.36	0.43	324.23	175.39
10.84	463.39	14.26	1322.79	150.72	350.32	499.60	650.32	300	149.28	3.35	0.43	324.44	175.16
11.05	463.76	14.54	1327.06	150.26	349.46	499.20	649.46	300	149.74	3.33	0.43	324.47	174.73
11.25	464.59	14.80	1331.16	149.51	349.01	499.50	649.01	300	150.49	3.32	0.43	325.00	174.51
11.46	466.20	15.08	1335.49	148.60	349.08	500.48	649.08	300	151.40	3.31	0.43	325.94	174.54
11.60	466.20	15.26	1338.40	148.32	348.33	500.01	648.33	300	151.68	3.30	0.43	325.84	174.16
11.80	466.23	15.53	1342.57	147.47	347.27	499.80	647.27	300	152.53	3.28	0.42	326.16	173.63
12.08	467.16	15.89	1348.45	146.44	346.44	500.00	646.44	300	153.56	3.26	0.42	326.78	173.22
12.22	469.14	16.08	1351.41	145.55	347.15	501.60	647.15	300	154.45	3.25	0.42	328.02	173.57
12.42	469.77	16.34	1355.66	145.16	346.52	501.36	646.52	300	154.84	3.24	0.42	328.10	173.26
12.63	469.77	16.62	1360.15	144.16	345.38	501.22	645.38	300	155.84	3.22	0.42	328.53	172.69
12.84	472.85	16.89	1364.67	143.70	346.50	502.80	646.50	300	156.30	3.22	0.41	329.55	173.25
13.04	473.44	17.16	1369.01	143.24	345.82	502.59	645.82	300	156.76	3.21	0.41	329.67	172.91
13.25	475.92	17.43	1373.59	142.85	346.48	503.63	646.48	300	157.15	3.20	0.41	330.39	173.24
13.46	475.66	17.71	1378.20	142.08	345.13	503.05	645.13	300	157.92	3.19	0.41	330.49	172.57
13.66	475.50	17.97	1382.62	141.39	343.91	502.52	643.91	300	158.61	3.17	0.41	330.57	171.96
13.87	475.62	18.25	1387.30	141.39	342.84	501.45	642.84	300	158.61	3.16	0.41	330.03	171.42
14.08	476.87	18.53	1392.00	141.24	342.58	501.34	642.58	300	158.76	3.16	0.41	330.05	171.29
14.28	476.87	18.79	1396.51	141.24	341.47	500.23	641.47	300	158.76	3.15	0.41	329.50	170.74
14.42	477.70	18.97	1399.69	140.08	341.29	501.21	641.29	300	159.92	3.13	0.41	330.56	170.64
14.66	478.58	19.29	1405.16	139.29	340.58	501.30	640.58	300	160.71	3.12	0.41	331.00	170.29

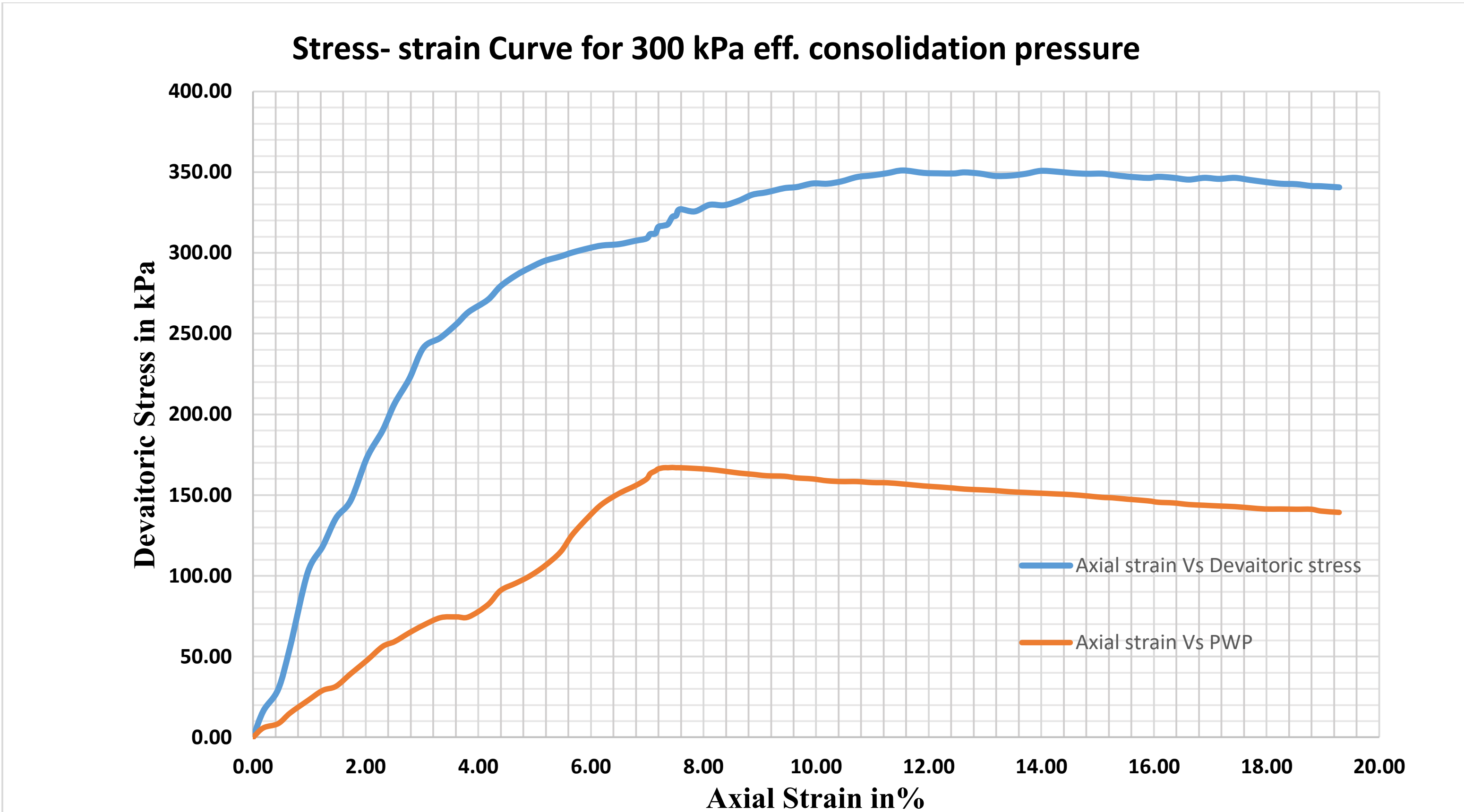


Fig.C.17. Stress-strain curves for Effective consolidation pressure of 300 kPa and strain rate of 0.1mm/min

Table C12. Compression stage result for 400 kPa effective consolidation pressure													
Location			Asela kebele 09 (chigign mefelfeya area				Job reference			thesis research			
soil Description			red brown clay				Pit number			1			
Test method			CU with measurement of pore water pressure; BS 1377: clause 8				sample no			1			
							Depth			3.00m			
Area in mm2		1134.11	strain rate(mm/min)			0.10	Effective stress (kPa)			400			
Axial Disp. (mm)	Change in force (N)	Axial strain (%)	Area Corrected (mm^2)	Change in pore pr. (kPa)	Deviator stress (kPa)	Principle stresses					Coefficient A (-)	Stress path parameters	
						Major (σ_1') (kPa)	major($\sigma1$) (kPa)	minor ($\sigma3$) kPa	Minor (σ_3') (kPa)	σ_1'/σ_3' (-)'		s' (kPa)	T (kPa)
0.00	0.00	0.00	1134.11	0.00	0.00	400.00	400.00	400	400.00	1.00	-	400.00	0.00
0.01	25.41	0.01	1134.26	2.33	22.40	420.07	422.40	400	397.67	1.06	0.10	408.87	11.20
0.14	78.21	0.18	1136.21	11.99	68.83	456.84	468.83	400	388.01	1.18	0.17	422.43	34.42
0.33	97.89	0.43	1139.06	19.33	85.94	466.61	485.94	400	380.67	1.23	0.22	423.64	42.97
0.52	126.71	0.68	1141.93	29.73	110.96	481.23	510.96	400	370.27	1.30	0.27	425.75	55.48
0.74	157.53	0.97	1145.27	43.19	137.55	494.36	537.55	400	356.81	1.39	0.31	425.58	68.78
0.96	188.11	1.26	1148.62	59.71	163.77	504.05	563.77	400	340.29	1.48	0.36	422.17	81.88
1.16	209.53	1.53	1151.69	75.61	181.93	506.32	581.93	400	324.39	1.56	0.42	415.35	90.97
1.35	225.16	1.78	1154.62	93.36	195.00	501.65	595.00	400	306.64	1.64	0.48	404.14	97.50
1.56	240.75	2.05	1157.88	106.20	207.92	501.72	607.92	400	293.80	1.71	0.51	397.76	103.96
1.75	261.50	2.30	1160.84	117.82	225.27	507.44	625.27	400	282.18	1.80	0.52	394.81	112.63
1.94	278.86	2.55	1163.82	132.51	239.61	507.10	639.61	400	267.49	1.90	0.55	387.30	119.80
2.15	292.44	2.83	1167.13	139.85	250.56	510.72	650.56	400	260.15	1.96	0.56	385.43	125.28
2.37	304.19	3.12	1170.62	153.90	259.86	505.95	659.86	400	246.10	2.06	0.59	376.03	129.93
2.57	319.90	3.38	1173.81	156.37	272.53	516.16	672.53	400	243.63	2.12	0.57	379.89	136.26
2.76	331.77	3.63	1176.85	164.32	281.92	517.59	681.92	400	235.68	2.20	0.58	376.63	140.96
2.99	342.34	3.93	1180.56	171.61	289.98	518.37	689.98	400	228.39	2.27	0.59	373.38	144.99
3.16	352.84	4.16	1183.32	177.17	298.18	521.01	698.18	400	222.83	2.34	0.59	371.92	149.09
3.35	364.14	4.41	1186.41	179.61	306.93	527.31	706.93	400	220.39	2.39	0.59	373.85	153.46
3.55	373.53	4.67	1189.69	183.30	313.97	530.68	713.97	400	216.70	2.45	0.58	373.69	156.99
3.75	384.37	4.93	1192.98	187.47	322.19	534.72	722.19	400	212.53	2.52	0.58	373.63	161.09
3.94	393.13	5.18	1196.12	191.24	328.67	537.43	728.67	400	208.76	2.57	0.58	373.10	164.34
4.15	403.43	5.46	1199.62	192.56	336.30	543.74	736.30	400	207.44	2.62	0.57	375.59	168.15

4.35	409.70	5.72	1202.97	194.54	340.57	546.03	740.57	400	205.46	2.66	0.57	375.74	170.29
4.54	417.98	5.97	1206.17	197.08	346.53	549.45	746.53	400	202.92	2.71	0.57	376.18	173.27
4.73	424.90	6.22	1209.38	197.97	351.33	553.36	751.33	400	202.03	2.74	0.56	377.70	175.67
4.93	429.21	6.49	1212.79	200.41	353.91	553.49	753.91	400	199.59	2.77	0.57	376.54	176.95
5.09	434.73	6.70	1215.52	203.47	357.65	554.17	757.65	400	196.53	2.82	0.57	375.35	178.82
5.31	443.59	6.99	1219.31	204.74	363.81	559.07	763.81	400	195.26	2.86	0.56	377.17	181.90
5.52	445.74	7.26	1222.94	204.70	364.48	559.78	764.48	400	195.30	2.87	0.56	377.54	182.24
5.73	450.90	7.54	1226.59	204.70	367.60	562.90	767.60	400	195.30	2.88	0.56	379.10	183.80
5.97	452.36	7.86	1230.80	205.86	367.53	561.67	767.53	400	194.14	2.89	0.56	377.91	183.77
6.15	458.99	8.09	1233.97	206.99	371.96	564.96	771.96	400	193.01	2.93	0.56	378.99	185.98
6.35	462.69	8.36	1237.51	206.71	373.89	567.17	773.89	400	193.29	2.93	0.55	380.23	186.94
6.56	467.17	8.63	1241.25	205.69	376.37	570.68	776.37	400	194.31	2.94	0.55	382.50	188.18
6.77	471.55	8.91	1245.02	206.99	378.75	571.76	778.75	400	193.01	2.96	0.55	382.38	189.38
6.95	477.40	9.14	1248.27	205.15	382.45	577.30	782.45	400	194.85	2.96	0.54	386.08	191.23
7.20	481.88	9.47	1252.80	205.69	384.64	578.96	784.64	400	194.31	2.98	0.53	386.63	192.32
7.42	482.56	9.76	1256.82	204.34	383.96	579.61	783.96	400	195.66	2.96	0.53	387.64	191.98
7.62	487.05	10.03	1260.50	203.00	386.39	583.39	786.39	400	197.00	2.96	0.53	390.20	193.20
7.82	489.19	10.29	1264.19	202.19	386.96	584.77	786.96	400	197.81	2.96	0.52	391.29	193.48
8.03	492.89	10.57	1268.10	201.11	388.68	587.58	788.68	400	198.89	2.95	0.52	393.24	194.34
8.22	494.35	10.82	1271.65	198.68	388.75	590.06	788.75	400	201.32	2.93	0.51	395.69	194.37
8.40	502.44	11.05	1275.04	197.87	394.06	596.19	794.06	400	202.13	2.95	0.50	399.16	197.03
8.59	504.68	11.30	1278.63	196.27	394.70	598.43	794.70	400	203.73	2.94	0.50	401.08	197.35
8.79	508.38	11.57	1282.44	196.36	396.42	600.06	796.42	400	203.64	2.95	0.50	401.85	198.21
8.99	511.32	11.83	1286.27	194.37	397.53	603.16	797.53	400	205.63	2.93	0.49	404.40	198.76
9.20	517.25	12.11	1290.31	193.02	400.87	607.85	800.87	400	206.98	2.94	0.48	407.41	200.44
9.40	517.44	12.37	1294.19	191.67	399.82	608.15	799.82	400	208.33	2.92	0.48	408.24	199.91
9.57	519.39	12.59	1297.50	190.33	400.30	609.98	800.30	400	209.67	2.91	0.48	409.82	200.15
9.75	523.09	12.83	1301.02	188.44	402.06	613.62	802.06	400	211.56	2.90	0.47	412.59	201.03
9.95	531.18	13.09	1304.96	188.71	407.05	618.34	807.05	400	211.29	2.93	0.46	414.81	203.52
10.16	530.33	13.37	1309.12	185.33	405.11	619.77	805.11	400	214.67	2.89	0.46	417.22	202.55
10.37	535.60	13.64	1313.31	184.81	407.83	623.01	807.83	400	215.19	2.90	0.45	419.10	203.91
10.58	539.58	13.92	1317.53	182.17	409.54	627.37	809.54	400	217.83	2.88	0.44	422.60	204.77
10.80	540.69	14.21	1321.97	182.69	409.00	626.31	809.00	400	217.31	2.88	0.45	421.81	204.50
11.02	543.75	14.50	1326.45	181.11	409.93	628.82	809.93	400	218.89	2.87	0.44	423.85	204.96
11.20	545.10	14.74	1330.13	181.11	409.81	628.70	809.81	400	218.89	2.87	0.44	423.79	204.91

11.41	547.96	15.01	1334.46	179.53	410.62	631.09	810.62	400	220.47	2.86	0.44	425.78	205.31
11.62	551.95	15.29	1338.81	177.94	412.27	634.33	812.27	400	222.06	2.86	0.43	428.20	206.14
11.83	554.60	15.57	1343.19	176.89	412.90	636.01	812.90	400	223.11	2.85	0.43	429.56	206.45
12.05	557.19	15.86	1347.81	176.75	413.41	636.66	813.41	400	223.25	2.85	0.43	429.95	206.70
12.26	557.19	16.13	1352.26	176.89	412.05	635.16	812.05	400	223.11	2.85	0.43	429.14	206.02
12.48	559.88	16.42	1356.94	175.30	412.61	637.31	812.61	400	224.70	2.84	0.42	431.01	206.30
12.68	561.27	16.68	1361.22	174.24	412.32	638.08	812.32	400	225.76	2.83	0.42	431.92	206.16
12.87	561.94	16.93	1365.32	172.65	411.58	638.93	811.58	400	227.35	2.81	0.42	433.14	205.79
13.06	566.17	17.18	1369.44	173.18	413.43	640.24	813.43	400	226.82	2.82	0.42	433.53	206.71
13.46	567.18	17.71	1378.20	173.57	411.54	637.97	811.54	400	226.43	2.82	0.42	432.20	205.77
13.65	569.85	17.96	1382.40	172.65	412.22	639.56	812.22	400	227.35	2.81	0.42	433.45	206.11
13.86	573.99	18.24	1387.07	172.75	413.81	641.06	813.81	400	227.25	2.82	0.42	434.15	206.91
14.07	574.84	18.51	1391.78	171.70	413.02	641.32	813.02	400	228.30	2.81	0.42	434.81	206.51
14.27	578.23	18.78	1396.29	170.79	414.12	643.33	814.12	400	229.21	2.81	0.41	436.27	207.06
14.48	580.57	19.05	1401.05	170.79	414.38	643.59	814.38	400	229.21	2.81	0.41	436.40	207.19
14.66	582.93	19.29	1405.16	169.34	414.85	645.51	814.85	400	230.66	2.80	0.41	438.08	207.43
14.84	585.82	19.53	1409.30	169.16	415.68	646.52	815.68	400	230.84	2.80	0.41	438.68	207.84
15.04	589.55	19.79	1413.92	168.98	416.96	647.98	816.96	400	231.02	2.80	0.41	439.50	208.48
15.24	590.09	20.05	1418.58	166.97	415.97	649.00	815.97	400	233.03	2.79	0.40	441.02	207.99
15.46	591.32	20.34	1423.73	164.96	415.33	650.38	815.33	400	235.04	2.77	0.40	442.71	207.67
15.68	594.05	20.63	1428.92	163.86	415.73	651.87	815.73	400	236.14	2.76	0.39	444.01	207.87
15.87	595.83	20.88	1433.44	162.76	415.67	652.91	815.67	400	237.24	2.75	0.39	445.07	207.83
16.11	598.99	21.20	1439.18	161.66	416.20	654.54	816.20	400	238.34	2.75	0.39	446.44	208.10
16.30	600.19	21.45	1443.76	160.93	415.71	654.78	815.71	400	239.07	2.74	0.39	446.92	207.86
16.51	601.93	21.72	1448.86	160.20	415.45	655.25	815.45	400	239.80	2.73	0.39	447.53	207.73
16.70	604.70	21.97	1453.50	159.47	416.03	656.56	816.03	400	240.53	2.73	0.38	448.55	208.01
16.91	607.28	22.25	1458.67	158.74	416.33	657.59	816.33	400	241.26	2.73	0.38	449.42	208.16
17.13	609.32	22.54	1464.12	158.01	416.17	658.16	816.17	400	241.99	2.72	0.38	450.08	208.08
17.34	611.71	22.82	1469.36	157.28	416.31	659.03	816.31	400	242.72	2.72	0.38	450.88	208.15
17.57	614.21	23.12	1475.15	156.54	416.37	659.83	816.37	400	243.46	2.71	0.38	451.64	208.19
17.76	616.48	23.37	1479.96	155.81	416.55	660.74	816.55	400	244.19	2.71	0.37	452.46	208.28
17.96	618.37	23.63	1485.06	155.08	416.39	661.31	816.39	400	244.92	2.70	0.37	453.12	208.20
18.15	620.35	23.88	1489.93	154.35	416.36	662.01	816.36	400	245.65	2.69	0.37	453.83	208.18
18.33	622.64	24.12	1494.59	153.62	416.59	662.98	816.59	400	246.38	2.69	0.37	454.68	208.30
18.54	624.73	24.39	1500.05	152.89	416.47	663.59	816.47	400	247.11	2.69	0.37	455.35	208.24

18.73	626.84	24.64	1505.02	152.16	416.50	664.34	816.50	400	247.84	2.68	0.37	456.09	208.25
18.94	629.19	24.92	1510.56	151.42	416.53	665.11	816.53	400	248.58	2.68	0.36	456.84	208.26
19.15	630.66	25.20	1516.14	150.69	415.96	665.27	815.96	400	249.31	2.67	0.36	457.29	207.98
19.33	631.43	25.43	1520.96	149.96	415.16	665.19	815.16	400	250.04	2.66	0.36	457.62	207.58
19.52	634.36	25.68	1526.08	149.23	415.68	666.45	815.68	400	250.77	2.66	0.36	458.61	207.84
19.72	638.12	25.95	1531.50	148.50	416.66	668.17	816.66	400	251.50	2.66	0.36	459.83	208.33
19.91	636.58	26.20	1536.69	147.77	414.25	666.49	814.25	400	252.23	2.64	0.36	459.36	207.13
20.11	638.74	26.46	1542.19	147.04	414.18	667.14	814.18	400	252.96	2.64	0.36	460.05	207.09
20.33	639.52	26.75	1548.28	146.304	413.05	666.75	813.05	400	253.70	2.63	0.35	460.22	206.53

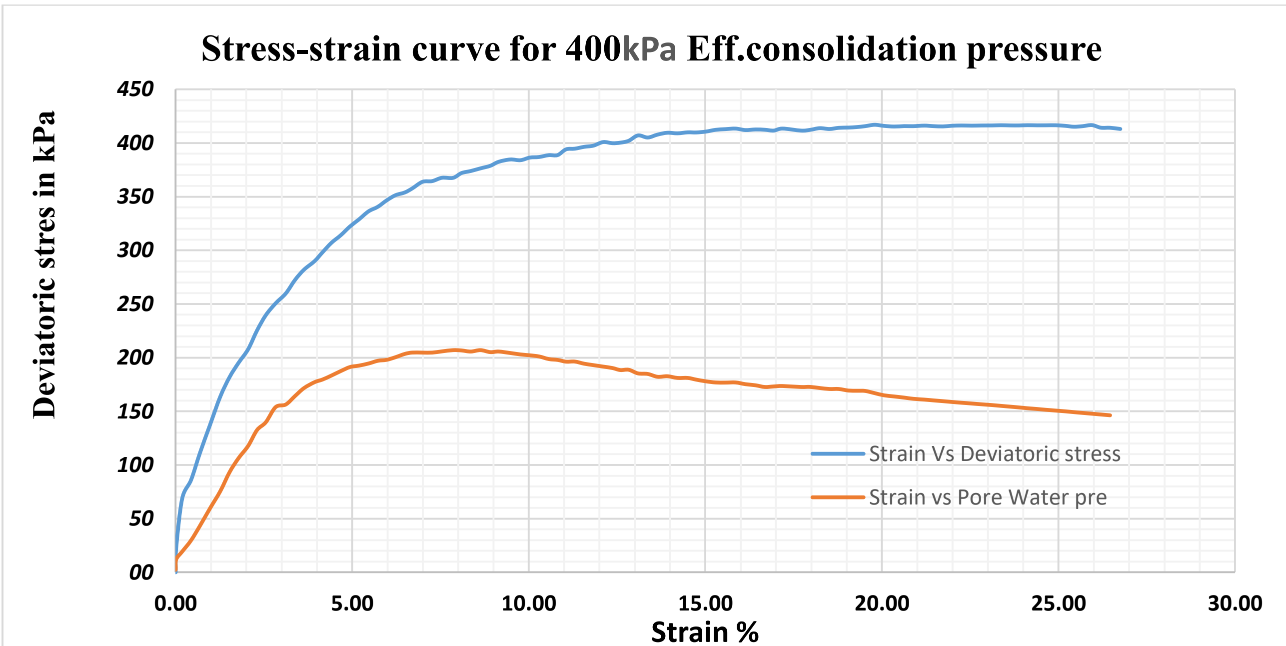


Fig.C.18. Stress-strain curves for Effective consolidation pressure of 400 kPa and strain rate of 0.1mm/min

1.4) Triaxial compression test result for strain rate 1mm/min

Table C13: consolidation Stage result for effective consolidation pressure of 200 kPa , 300 kPa and 400 kPa

Location: Asela kebele 09 (chigign mefelfeya)						**Job reference**		**Thesis research**
Soil Description: Red brown Clay						**pit No**		**#1**
Test Method: CU with pore water pressure measurement, BS 1377,clause 8						**sample No**		**#1**
						Depth		**2.8m**
Remolded soil								
Effective consolidation pressure of 200 kPa			**Effective consolidation pressure of 300 kPa**			**Effective consolidation pressure of 400 kPa**		
Initial condition	**CP,kPa**	**500**	**Initial condition**	**CP, kPa**	**700**	**Initial condition**	**CP, kPa**	**750**
	BP, kPa	**300**		**BP, kPa**	**400**		**BP, kPa**	**350**
	PP, kPa	**446.58**		**PP, kPa**	**524.14**		**PP, kPa**	**605.71**
Final condition	**PP, kPa**	**268.37**	**Final condition**	**PP, kPa**	**270.31**	**Final condition**	**PP, kPa**	**271.59**
	∆volume,	**3.9**		**∆volum**	**4.598**		**∆volume**	**5.73**
	%consolidation	**98.9**		**%consolidation**	**97.9**		**%consolidation**	**99.36**
Sqrt of time	**∆volume, mm**	**PP,kPa**	**Sqrt of time**	**∆volume,mm**	**PP,kPa**	**Sqrt of time**	**∆volume ,mm**	**PP,kPa**
0.00	3.750	446.66	0.29	4.656	525.14	0.360	6.25	605.71
0.44	3.510	270.15	0.36	4.646	525.29	0.440	5.50	272.66
0.54	3.480	269.77	0.44	4.070	270.93	0.540	5.37	272.04
0.66	3.440	269.61	0.54	4.070	270.62	0.660	5.27	271.66
0.81	3.338	269.45	0.66	4.070	270.16	0.810	5.27	271.34
1.00	3.290	269.37	0.81	4.032	270	1.000	5.20	271.19
1.22	3.285	269.37	1.00	3.946	269.93	1.220	5.20	271.03
1.49	3.224	269.30	1.22	3.907	269.85	1.490	5.06	270.88
1.83	3.101	269.14	1.49	3.783	269.77	1.830	5.02	271.42
2.24	3.101	269.07	1.83	3.706	269.62	2.240	4.89	270.58
2.74	3.048	268.92	2.24	3.581	269.62	2.740	4.77	270.58
3.36	2.925	268.92	2.74	3.420	269.46	3.360	4.65	270.50
4.11	2.740	268.99	3.36	3.331	269.54	4.110	4.41	270.42
5.04	2.608	268.92	4.11	3.168	269.62	5.040	4.12	270.58
6.17	2.380	268.92	5.04	2.960	269.62	6.170	3.83	270.65
7.56	2.098	269.14	6.17	2.630	269.85	7.560	3.46	270.96
9.26	1.763	268.99	7.56	2.342	269.85	9.260	3.04	271.11
11.34	1.446	268.99	9.26	1.929	269.93	11.340	2.54	271.42
13.89	1.138	269.14	11.34	1.517	270.05	13.890	1.93	271.66
17.01	0.874	269.14	13.89	1.190	270.22	17.010	1.39	272.04
20.83	0.557	268.92	17.01	0.778	270.31	20.830	0.95	272.27
25.51	0.380	268.84	20.83	0.403	270.41	25.510	0.61	272.04
31.25	0.320	268.38	25.51	0.163	270.31	31.250	0.52	271.59
			32.25	0.058	270.31			

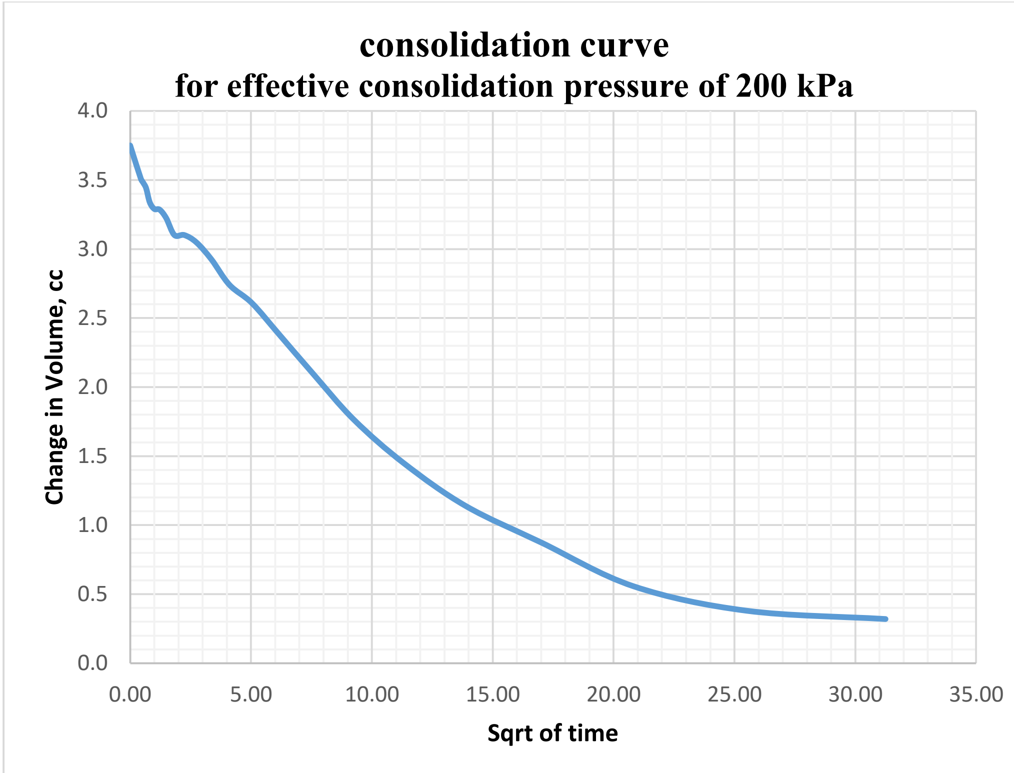


Fig C.19. Consolidation curve for effective consolidation pressure of 200 kPa

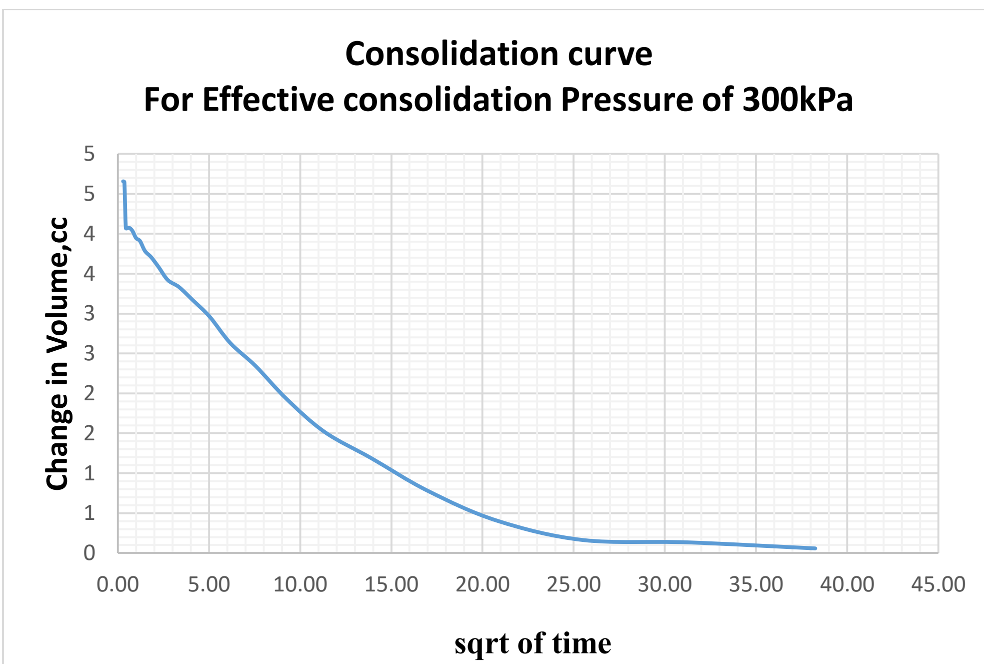


Fig C.20. Consolidation curve for effective consolidation pressure of 300 kPa

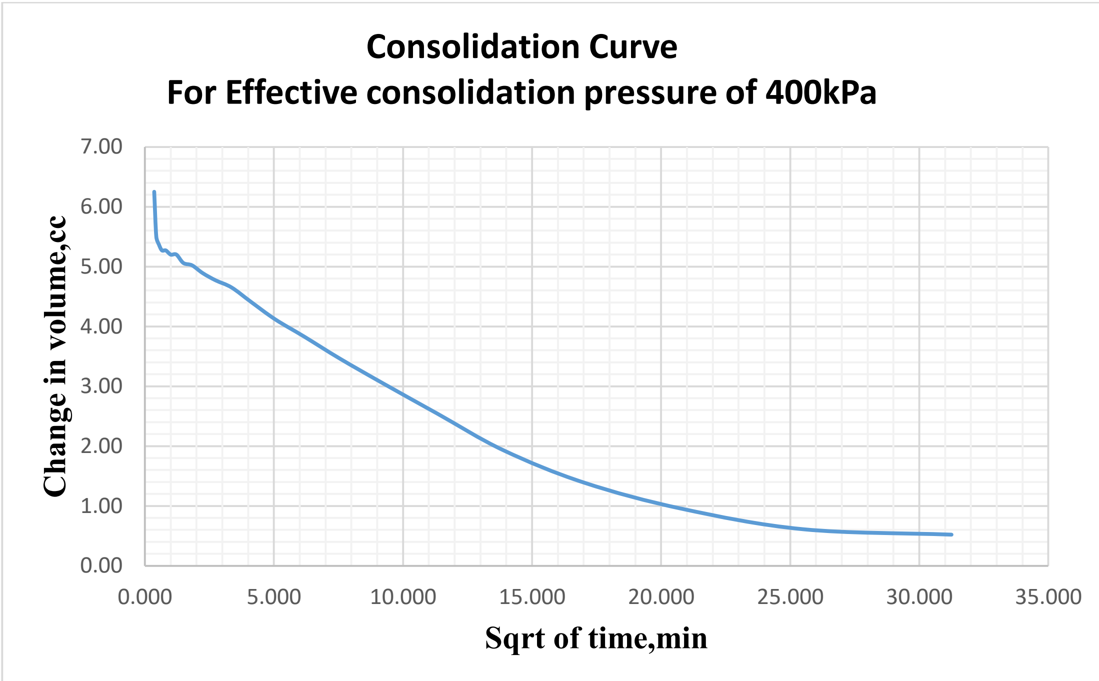


Fig C.21. Consolidation curve for effective consolidation pressure of 400 kPa

Table C14. Compression stage result for 200 kPa effective consolidation pressure													
Location		Asela kebele 09 (chigign mefelfeya area					Job reference			thesis research			
soil Description		red brown clay					Pit number			1			
Test method		CU with measurement of pore water pressure; BS 1377: clause 8					sample no			1			
							depth			3.00m			
Area in mm2		1134.115	strain rate(mm/min)		1.00		Effective stress (kPa)			200			
Axial Disp. (mm)	Change in Force (N)	Axial strain (%)	Area corrected (mm²)	Change in pore pr. (kPa)	Deviator stress (kPa)	Principle stresses: Major (σ_1') (kPa)	major(σ_1) (kPa)	minor (σ_3) kPa	Minor (σ_3') (kPa)	σ_1'/σ_3' (-)'	Coefficient A (-)	Stress path pameter: s' (kPa)	T (kPa)
0.00	0.00	0.00	1134.11	0.00	0.00	200.00	200.00	200	200.00	1.00	-	200.00	0.00
0.14	12.31	0.18	1136.21	3.38	10.83	207.46	210.83	200	196.62	1.06	0.31	202.04	5.42
0.34	122.47	0.45	1139.21	8.56	107.50	298.95	307.50	200	191.44	1.56	0.08	245.20	53.75
0.50	189.87	0.66	1141.63	12.51	166.32	353.80	366.32	200	187.49	1.89	0.08	270.65	83.16
0.74	237.69	0.97	1145.27	18.34	207.54	389.20	407.54	200	181.66	2.14	0.09	285.43	103.77
0.94	267.40	1.24	1148.32	23.12	232.87	409.75	432.87	200	176.88	2.32	0.10	293.31	116.43
1.12	277.54	1.47	1151.08	27.22	241.12	413.89	441.12	200	172.78	2.40	0.11	293.34	120.56
1.32	306.53	1.74	1154.16	29.34	265.59	436.25	465.59	200	170.66	2.56	0.11	303.46	132.79
1.54	323.20	2.03	1157.57	32.66	279.20	446.54	479.20	200	167.34	2.67	0.12	306.94	139.60
1.75	341.32	2.30	1160.84	34.51	294.03	459.52	494.03	200	165.49	2.78	0.12	312.50	147.01
1.91	350.65	2.51	1163.35	35.79	301.42	465.63	501.42	200	164.21	2.84	0.12	314.92	150.71
2.11	361.61	2.78	1166.50	37.51	309.99	472.49	509.99	200	162.49	2.91	0.12	317.49	155.00
2.30	374.65	3.03	1169.51	40.52	320.35	479.83	520.35	200	159.48	3.01	0.13	319.66	160.17
2.53	386.25	3.33	1173.17	42.24	329.23	487.00	529.23	200	157.76	3.09	0.13	322.38	164.62
2.75	402.19	3.62	1176.69	44.39	341.80	497.41	541.80	200	155.61	3.20	0.13	326.51	170.90
2.91	413.06	3.83	1179.27	47.40	350.27	502.87	550.27	200	152.60	3.30	0.14	327.74	175.13
3.17	418.86	4.17	1183.48	49.12	353.92	504.80	553.92	200	150.88	3.35	0.14	327.84	176.96
3.34	426.83	4.39	1186.25	49.97	359.82	509.84	559.82	200	150.03	3.40	0.14	329.93	179.91
3.55	434.08	4.67	1189.69	50.84	364.87	514.03	564.87	200	149.16	3.45	0.14	331.59	182.43
3.73	434.81	4.91	1192.65	52.13	364.57	512.44	564.57	200	147.87	3.47	0.14	330.16	182.29
3.93	440.60	5.17	1195.96	53.42	368.41	514.99	568.41	200	146.58	3.51	0.14	330.79	184.21
4.15	450.75	5.46	1199.62	54.27	375.75	521.47	575.75	200	145.73	3.58	0.14	333.60	187.87
4.31	454.37	5.67	1202.30	55.14	377.91	522.78	577.91	200	144.86	3.61	0.15	333.82	188.96

4.53	457.27	5.96	1206.00	56.86	379.16	522.31	579.16	200	143.14	3.65	0.15	332.72	189.58
4.71	460.89	6.20	1209.04	57.28	381.20	523.92	581.20	200	142.72	3.67	0.15	333.32	190.60
4.94	468.14	6.50	1212.96	57.71	385.95	528.23	585.95	200	142.29	3.71	0.15	335.26	192.97
5.16	471.76	6.79	1216.72	59.86	387.73	527.86	587.73	200	140.14	3.77	0.15	334.00	193.86
5.31	471.76	6.99	1219.31	59.86	386.91	527.04	586.91	200	140.14	3.76	0.15	333.59	193.45
5.36	473.93	7.05	1220.17	60.30	388.42	528.12	588.42	200	139.70	3.78	0.16	333.91	194.21
5.43	476.83	7.14	1221.38	60.30	390.40	530.10	590.40	200	139.70	3.79	0.15	334.90	195.20
5.47	473.21	7.20	1222.07	60.72	387.22	526.50	587.22	200	139.28	3.78	0.16	332.89	193.61
5.54	476.83	7.29	1223.29	60.72	389.79	529.07	589.79	200	139.28	3.80	0.16	334.18	194.90
5.60	477.56	7.37	1224.33	60.72	390.06	529.34	590.06	200	139.28	3.80	0.16	334.31	195.03
5.66	477.56	7.45	1225.37	60.72	389.72	529.00	589.72	200	139.28	3.80	0.16	334.14	194.86
5.71	476.83	7.51	1226.24	60.72	388.85	528.13	588.85	200	139.28	3.79	0.16	333.71	194.43
5.76	477.56	7.58	1227.12	62.01	389.17	527.16	589.17	200	137.99	3.82	0.16	332.58	194.58
5.96	481.91	7.84	1230.62	62.44	391.60	529.16	591.60	200	137.56	3.85	0.16	333.36	195.80
6.16	482.63	8.11	1234.15	62.01	391.06	529.05	591.06	200	137.99	3.83	0.16	333.52	195.53
6.36	484.08	8.37	1237.69	63.31	391.12	527.81	591.12	200	136.69	3.86	0.16	332.25	195.56
6.56	482.63	8.63	1241.25	62.87	388.82	525.95	588.82	200	137.13	3.84	0.16	331.54	194.41
6.74	484.50	8.87	1244.48	64.59	389.31	524.72	589.31	200	135.41	3.88	0.17	330.06	194.66
6.93	486.25	9.12	1247.90	64.59	389.65	525.06	589.65	200	135.41	3.88	0.17	330.23	194.83
7.17	492.05	9.43	1252.26	66.31	392.93	526.61	592.93	200	133.69	3.94	0.17	330.15	196.46
7.34	495.10	9.66	1255.36	66.31	394.39	528.08	594.39	200	133.69	3.95	0.17	330.88	197.20
7.55	497.62	9.93	1259.21	65.45	395.19	529.74	595.19	200	134.55	3.94	0.17	332.15	197.59
7.75	500.18	10.20	1262.90	65.88	396.06	530.18	596.06	200	134.12	3.95	0.17	332.15	198.03
7.94	502.76	10.45	1266.42	66.31	396.99	530.68	596.99	200	133.69	3.97	0.17	332.18	198.50
8.15	504.61	10.72	1270.34	66.31	397.22	530.91	597.22	200	133.69	3.97	0.17	332.30	198.61
8.36	507.54	11.00	1274.29	67.17	398.30	531.13	598.30	200	132.83	4.00	0.17	331.98	199.15
8.56	510.38	11.26	1278.07	66.31	399.34	533.02	599.34	200	133.69	3.99	0.17	333.36	199.67
8.77	514.59	11.54	1282.06	66.74	401.38	534.64	601.38	200	133.26	4.01	0.17	333.95	200.69
9.05	516.74	11.91	1287.42	67.17	401.38	534.21	601.38	200	132.83	4.02	0.17	333.52	200.69
9.25	518.90	12.17	1291.28	67.17	401.85	534.68	601.85	200	132.83	4.03	0.17	333.76	200.92
9.46	520.25	12.45	1295.35	68.03	401.63	533.59	601.63	200	131.97	4.04	0.17	332.78	200.81
9.60	523.16	12.63	1298.08	68.89	403.03	534.14	603.03	200	131.11	4.07	0.17	332.62	201.51
9.81	526.97	12.91	1302.20	68.89	404.67	535.79	604.67	200	131.11	4.09	0.17	333.45	202.34
10.01	526.95	13.17	1306.15	69.75	403.44	533.69	603.44	200	130.25	4.10	0.17	331.97	201.72
10.22	530.63	13.45	1310.32	68.46	404.96	536.50	604.96	200	131.54	4.08	0.17	334.02	202.48

10.43	534.39	13.72	1314.51	69.75	406.53	536.78	606.53	200	130.25	4.12	0.17	333.52	203.26
10.63	536.61	13.99	1318.54	69.32	406.97	537.65	606.97	200	130.68	4.11	0.17	334.16	203.49
10.84	540.41	14.26	1322.79	70.61	408.54	537.93	608.54	200	129.39	4.16	0.17	333.66	204.27
11.05	542.76	14.54	1327.06	69.75	408.99	539.25	608.99	200	130.25	4.14	0.17	334.75	204.50
11.25	548.21	14.80	1331.16	69.75	411.82	542.08	611.82	200	130.25	4.16	0.17	336.17	205.91
11.46	549.12	15.08	1335.49	70.18	411.17	540.99	611.17	200	129.82	4.17	0.17	335.41	205.59
11.60	551.62	15.26	1338.40	69.75	412.15	542.40	612.15	200	130.25	4.16	0.17	336.33	206.07
11.80	555.41	15.53	1342.57	69.75	413.69	543.95	613.69	200	130.25	4.18	0.17	337.10	206.85
12.08	559.63	15.89	1348.45	69.69	415.02	545.33	615.02	200	130.31	4.18	0.17	337.82	207.51
12.22	560.63	16.08	1351.41	70.18	414.85	544.67	614.85	200	129.82	4.20	0.17	337.25	207.42
12.42	561.88	16.34	1355.66	70.18	414.47	544.29	614.47	200	129.82	4.19	0.17	337.06	207.24
12.63	562.34	16.62	1360.15	70.18	413.44	543.26	613.44	200	129.82	4.18	0.17	336.54	206.72
12.84	564.35	16.89	1364.67	69.75	413.54	543.80	613.54	200	130.25	4.17	0.17	337.03	206.77
13.04	566.36	17.16	1369.01	69.75	413.70	543.95	613.70	200	130.25	4.18	0.17	337.10	206.85
13.25	566.79	17.43	1373.59	70.61	412.63	542.02	612.63	200	129.39	4.19	0.17	335.71	206.32
13.46	568.06	17.71	1378.20	71.04	412.18	541.13	612.18	200	128.96	4.20	0.17	335.05	206.09
13.66	570.12	17.97	1382.62	70.91	412.35	541.43	612.35	200	129.09	4.19	0.17	335.26	206.17
13.87	571.32	18.25	1387.30	71.15	411.82	540.67	611.82	200	128.85	4.20	0.17	334.76	205.91
14.08	574.22	18.53	1392.00	70.91	412.52	541.60	612.52	200	129.09	4.20	0.17	335.34	206.26
14.28	576.24	18.79	1396.51	70.91	412.63	541.71	612.63	200	129.09	4.20	0.17	335.40	206.31
14.42	576.37	18.97	1399.69	71.04	411.79	540.74	611.79	200	128.96	4.19	0.17	334.85	205.89
14.63	574.15	19.25	1404.48	70.91	408.80	537.88	608.80	200	129.09	4.17	0.17	333.49	204.40
14.84	575.40	19.53	1409.30	71.38	408.29	536.91	608.29	200	128.62	4.17	0.17	332.76	204.14
15.04	577.72	19.79	1413.92	70.91	408.59	537.68	608.59	200	129.09	4.17	0.17	333.38	204.30
15.25	579.23	20.07	1418.81	71.85	408.25	536.40	608.25	200	128.15	4.19	0.18	332.27	204.12
15.45	583.19	20.33	1423.50	72.32	409.69	537.37	609.69	200	127.68	4.21	0.18	332.52	204.85
15.66	584.73	20.61	1428.45	71.38	409.34	537.96	609.34	200	128.62	4.18	0.17	333.29	204.67
15.87	588.59	20.88	1433.44	72.33	410.61	538.28	610.61	200	127.67	4.22	0.18	332.98	205.31
16.14	592.31	21.24	1439.91	73.27	411.35	538.08	611.35	200	126.73	4.25	0.18	332.41	205.68
16.35	593.12	21.51	1444.97	72.09	410.47	538.38	610.47	200	127.91	4.21	0.18	333.14	205.24
16.56	595.51	21.79	1450.08	72.09	410.67	538.58	610.67	200	127.91	4.21	0.18	333.25	205.34
16.70	599.93	21.97	1453.50	71.62	412.75	541.12	612.75	200	128.38	4.22	0.17	334.75	206.37
16.90	602.67	22.24	1458.42	73.03	413.23	540.20	613.23	200	126.97	4.25	0.18	333.59	206.62
17.11	604.08	22.51	1463.62	72.56	412.73	540.17	612.73	200	127.44	4.24	0.18	333.80	206.36
17.32	605.74	22.79	1468.86	71.15	412.39	541.24	612.39	200	128.85	4.20	0.17	335.04	206.19

17.52	610.67	23.05	1473.88	72.56	414.33	541.77	614.33	200	127.44	4.25	0.18	334.60	207.16
17.73	612.36	23.33	1479.20	72.32	413.98	541.66	613.98	200	127.68	4.24	0.17	334.67	206.99
17.94	614.95	23.61	1484.55	73.19	414.24	541.05	614.24	200	126.81	4.27	0.18	333.93	207.12
18.07	614.74	23.78	1487.88	71.85	413.17	541.31	613.17	200	128.15	4.22	0.17	334.73	206.58

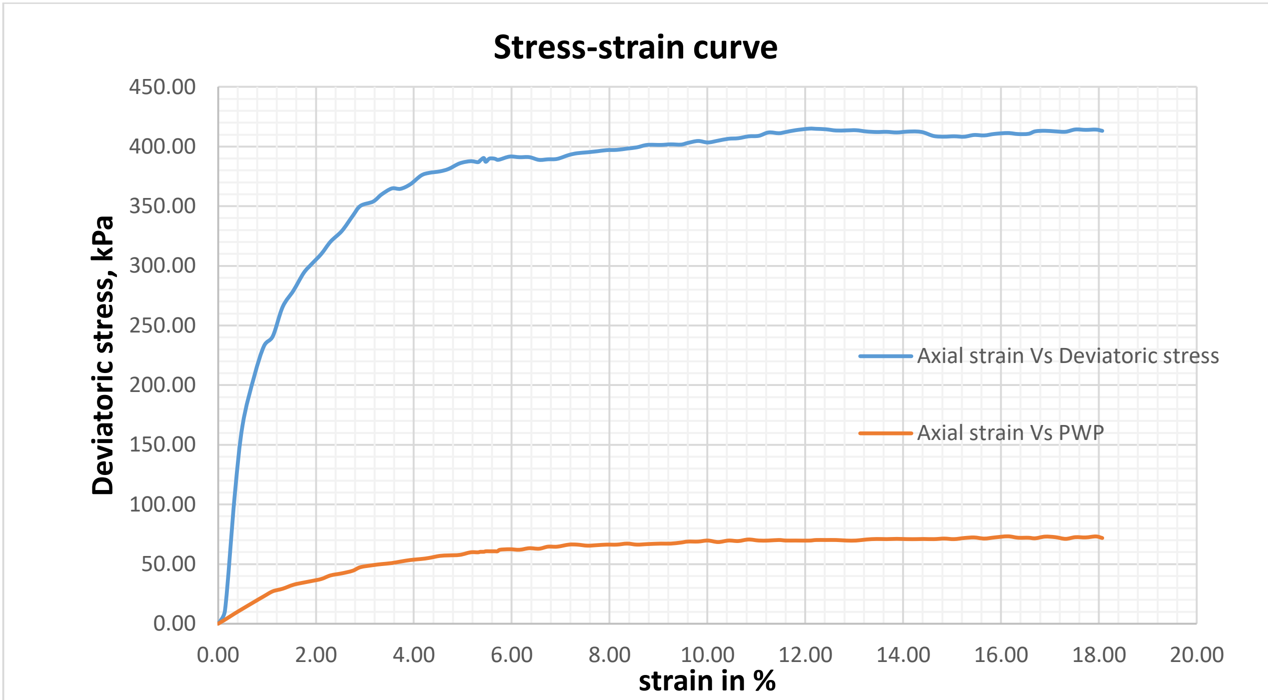


Fig.C.22. Stress-strain curves for Effective consolidation pressure of 200 kPa and strain rate of 1mm/min

Table C15. Compression stage result for 300 kPa effective consolidation pressure													
Location			Asela kebele 09 (chigign mefelfeya area					Job reference			thesis research		
soil Description			red brown clay					Pit number			1		
Test method			CU with measurement of pore water pressure; BS 1377: clause 8					sample no			1		
								depth			3.00m		
Area in mm2		1134.115	strain rate(mm/min)			1.00					Effective stress (kPa)		300
Axial Disp. (mm)	Change in Force (N)	Axial strain (%)	Area corrected (mm2)	Change in pore pr. (kPa)	Deviator stress (kPa)	Principle stresses: Major (□1') (kPa)	major(σ 1) (kPa)	minor (σ3) kPa	Minor (□3') (kPa)	□1'/□3' (-)'	Coefficient A (-)	Stress path parameters: s' (kPa)	T (kPa)
0.00	0.00	0.00	1134.11	0.00	0.00	300.00	300.00	300	300.00	1.00	-	300.00	0.00
0.14	11.80	0.18	1136.21	3.64	10.39	306.75	310.39	300	296.36	1.04	0.35	301.55	5.19
0.32	132.36	0.42	1138.91	10.08	116.22	406.13	416.22	300	289.92	1.40	0.09	348.03	58.11
0.52	200.85	0.68	1141.93	15.96	175.89	459.93	475.89	300	284.04	1.62	0.09	371.98	87.95
0.73	234.77	0.96	1145.11	26.28	205.02	478.74	505.02	300	273.72	1.75	0.13	376.23	102.51
0.91	281.48	1.20	1147.86	31.34	245.22	513.89	545.22	300	268.66	1.91	0.13	391.28	122.61
1.12	310.02	1.47	1151.08	34.44	269.33	534.89	569.33	300	265.56	2.01	0.13	400.22	134.67
1.35	334.28	1.78	1154.62	39.85	289.52	549.66	589.52	300	260.15	2.11	0.14	404.90	144.76
1.53	345.70	2.01	1157.42	42.68	298.68	556.00	598.68	300	257.32	2.16	0.14	406.66	149.34
1.72	358.91	2.26	1160.38	46.92	309.31	562.39	609.31	300	253.08	2.22	0.15	407.73	154.65
1.92	371.05	2.53	1163.51	50.45	318.91	568.46	618.91	300	249.55	2.28	0.16	409.00	159.45
2.14	382.44	2.82	1166.97	53.49	327.72	574.23	627.72	300	246.51	2.33	0.16	410.37	163.86
2.32	393.89	3.05	1169.83	56.80	336.71	579.91	636.71	300	243.20	2.38	0.17	411.55	168.35
2.50	404.58	3.29	1172.69	59.86	345.00	585.14	645.00	300	240.14	2.44	0.17	412.64	172.50
2.77	421.69	3.64	1177.01	64.10	358.27	594.18	658.27	300	235.90	2.52	0.18	415.04	179.14
2.94	428.82	3.87	1179.75	66.45	363.48	597.03	663.48	300	233.55	2.56	0.18	415.29	181.74
3.17	437.06	4.17	1183.48	69.52	369.30	599.78	669.30	300	230.48	2.60	0.19	415.13	184.65
3.36	444.52	4.42	1186.57	72.34	374.62	602.28	674.62	300	227.66	2.65	0.19	414.97	187.31
3.58	451.30	4.71	1190.18	74.46	379.18	604.73	679.18	300	225.54	2.68	0.20	415.14	189.59
3.98	462.36	5.24	1196.79	77.28	386.34	609.06	686.34	300	222.72	2.73	0.20	415.89	193.17
4.06	465.58	5.34	1198.12	78.93	388.60	609.67	688.60	300	221.07	2.76	0.20	415.37	194.30

4.21	470.22	5.54	1200.62	79.87	391.65	611.78	691.65	300	220.13	2.78	0.20	415.96	195.82
4.43	477.71	5.83	1204.31	80.81	396.67	615.85	696.67	300	219.19	2.81	0.20	417.52	198.33
4.61	480.58	6.07	1207.35	82.46	398.05	615.59	698.05	300	217.54	2.83	0.21	416.56	199.02
4.85	485.55	6.38	1211.42	84.11	400.81	616.70	700.81	300	215.89	2.86	0.21	416.30	200.40
5.03	490.53	6.62	1214.50	85.28	403.90	618.62	703.90	300	214.72	2.88	0.21	416.67	201.95
5.25	495.56	6.91	1218.27	86.93	406.77	619.84	706.77	300	213.07	2.91	0.21	416.45	203.39
5.42	502.71	7.13	1221.21	87.87	411.65	623.78	711.65	300	212.13	2.94	0.21	417.95	205.82
5.65	506.62	7.43	1225.20	88.81	413.50	624.69	713.50	300	211.19	2.96	0.21	417.94	206.75
5.77	506.63	7.59	1227.29	89.05	412.81	623.76	712.81	300	210.95	2.96	0.22	417.36	206.40
6.09	509.45	8.01	1232.91	89.76	413.21	623.45	713.21	300	210.24	2.97	0.22	416.85	206.60
6.25	510.89	8.22	1235.74	91.87	413.43	621.56	713.43	300	208.13	2.99	0.22	414.85	206.72
6.45	515.18	8.49	1239.29	92.58	415.71	623.13	715.71	300	207.42	3.00	0.22	415.27	207.85
6.66	518.76	8.76	1243.04	93.99	417.33	623.34	717.33	300	206.01	3.03	0.23	414.68	208.67
6.86	516.97	9.03	1246.64	94.46	414.69	620.23	714.69	300	205.54	3.02	0.23	412.89	207.34
7.13	520.20	9.38	1251.53	94.93	415.66	620.72	715.66	300	205.07	3.03	0.23	412.89	207.83
7.33	519.40	9.64	1255.17	95.87	413.81	617.94	713.81	300	204.13	3.03	0.23	411.03	206.91
7.51	522.84	9.88	1258.47	96.11	415.45	619.34	715.45	300	203.89	3.04	0.23	411.61	207.73
7.70	527.44	10.13	1261.97	97.05	417.95	620.89	717.95	300	202.95	3.06	0.23	411.92	208.97
7.94	529.83	10.45	1266.42	96.11	418.37	622.25	718.37	300	203.89	3.05	0.23	413.07	209.18
8.15	532.60	10.72	1270.34	97.05	419.25	622.20	719.25	300	202.95	3.07	0.23	412.58	209.63
8.35	535.23	10.99	1274.10	97.49	420.08	622.59	720.08	300	202.51	3.07	0.23	412.55	210.04
8.55	537.75	11.25	1277.88	98.46	420.81	622.36	720.81	300	201.54	3.09	0.23	411.95	210.41
8.76	537.45	11.53	1281.87	98.93	419.28	620.35	719.28	300	201.07	3.09	0.24	410.71	209.64
8.96	542.80	11.79	1285.69	99.64	422.19	622.55	722.19	300	200.36	3.11	0.24	411.46	211.09
9.10	545.98	11.97	1288.38	100.58	423.77	623.19	723.77	300	199.42	3.13	0.24	411.30	211.89
9.34	547.46	12.29	1293.02	101.28	423.39	622.11	723.39	300	198.72	3.13	0.24	410.41	211.70
9.52	551.42	12.53	1296.52	101.99	425.31	623.32	725.31	300	198.01	3.15	0.24	410.66	212.65
9.73	554.31	12.80	1300.63	101.99	426.19	624.19	726.19	300	198.01	3.15	0.24	411.10	213.09
9.94	556.36	13.08	1304.76	102.70	426.41	623.71	726.41	300	197.30	3.16	0.24	410.50	213.20
10.14	559.89	13.34	1308.73	103.17	427.82	624.65	727.82	300	196.83	3.17	0.24	410.74	213.91
10.34	562.28	13.61	1312.71	103.17	428.33	625.16	728.33	300	196.83	3.18	0.24	411.00	214.17
10.54	566.56	13.87	1316.72	103.88	430.28	626.41	730.28	300	196.12	3.19	0.24	411.26	215.14
10.75	568.69	14.14	1320.96	104.32	430.51	626.19	730.51	300	195.68	3.20	0.24	410.94	215.26

10.95	573.56	14.41	1325.02	104.82	432.86	628.05	732.86	300	195.18	3.22	0.24	411.62	216.43
11.16	575.70	14.68	1329.31	105.05	433.08	628.03	733.08	300	194.95	3.22	0.24	411.49	216.54
11.37	579.85	14.96	1333.63	105.05	434.79	629.73	734.79	300	194.95	3.23	0.24	412.34	217.39
11.57	580.59	15.22	1337.77	104.82	434.00	629.18	734.00	300	195.18	3.22	0.24	412.18	217.00
11.78	585.14	15.50	1342.15	106.70	435.97	629.27	735.97	300	193.30	3.26	0.24	411.28	217.99
11.98	587.11	15.76	1346.34	105.75	436.08	630.32	736.08	300	194.25	3.24	0.24	412.28	218.04
12.19	591.02	16.04	1350.77	105.52	437.54	632.02	737.54	300	194.48	3.25	0.24	413.25	218.77
12.33	592.92	16.22	1353.74	105.99	437.99	631.99	737.99	300	194.01	3.26	0.24	413.00	218.99
12.60	594.90	16.58	1359.51	105.99	437.58	631.59	737.58	300	194.01	3.26	0.24	412.80	218.79
12.60	597.76	16.58	1359.51	106.70	439.69	632.99	739.69	300	193.30	3.27	0.24	413.14	219.84
12.81	599.53	16.86	1364.02	106.46	439.53	633.07	739.53	300	193.54	3.27	0.24	413.30	219.76
12.94	600.96	17.03	1366.84	106.70	439.67	632.97	739.67	300	193.30	3.27	0.24	413.14	219.84
13.08	602.08	17.21	1369.88	106.93	439.52	632.59	739.52	300	193.07	3.28	0.24	412.83	219.76
13.22	604.25	17.39	1372.93	106.70	440.11	633.41	740.11	300	193.30	3.28	0.24	413.36	220.06
13.43	606.02	17.67	1377.54	106.46	439.93	633.47	739.93	300	193.54	3.27	0.24	413.50	219.97
13.63	610.48	17.93	1381.96	106.70	441.75	635.04	741.75	300	193.30	3.29	0.24	414.17	220.87
13.84	609.64	18.21	1386.63	106.93	439.66	632.72	739.66	300	193.07	3.28	0.24	412.90	219.83
14.04	611.46	18.47	1391.10	107.64	439.55	631.91	739.55	300	192.36	3.29	0.24	412.14	219.78
14.25	614.39	18.75	1395.83	107.64	440.16	632.52	740.16	300	192.36	3.29	0.24	412.44	220.08
14.46	618.07	19.03	1400.60	107.64	441.29	633.65	741.29	300	192.36	3.29	0.24	413.00	220.64
14.66	615.62	19.29	1405.16	108.35	438.11	629.76	738.11	300	191.65	3.29	0.25	410.71	219.06
14.80	620.82	19.47	1408.38	108.35	440.80	632.45	740.80	300	191.65	3.30	0.25	412.05	220.40
15.07	623.66	19.83	1414.62	108.82	440.87	632.05	740.87	300	191.18	3.31	0.25	411.62	220.43
15.28	623.81	20.11	1419.51	108.58	439.45	630.87	739.45	300	191.42	3.30	0.25	411.15	219.73
15.42	625.09	20.29	1422.79	108.58	439.34	630.76	739.34	300	191.42	3.30	0.25	411.09	219.67
15.62	627.66	20.55	1427.50	109.53	439.69	630.16	739.69	300	190.47	3.31	0.25	410.32	219.85
15.83	626.28	20.83	1432.49	109.76	437.20	627.44	737.20	300	190.24	3.30	0.25	408.84	218.60
16.04	632.25	21.11	1437.50	109.53	439.83	630.30	739.83	300	190.47	3.31	0.25	410.39	219.91
16.24	632.25	21.37	1442.31	110.23	438.36	628.13	738.36	300	189.77	3.31	0.25	408.95	219.18
16.45	634.06	21.64	1447.40	110.00	438.07	628.08	738.07	300	190.00	3.31	0.25	409.04	219.04
16.65	634.96	21.91	1452.28	110.00	437.21	627.22	737.21	300	190.00	3.30	0.25	408.61	218.61
16.86	637.14	22.18	1457.44	110.93	437.16	626.23	737.16	300	189.07	3.31	0.25	407.65	218.58
17.09	639.06	22.49	1463.13	110.93	436.78	625.84	736.78	300	189.07	3.31	0.25	407.45	218.39
17.26	640.32	22.71	1467.36	111.40	436.38	624.97	736.38	300	188.60	3.31	0.26	406.78	218.19
17.48	641.98	23.00	1472.88	111.87	435.87	623.99	735.87	300	188.13	3.32	0.26	406.06	217.93

17.70	643.63	23.29	1478.43	111.40	435.35	623.94	735.35	300	188.60	3.31	0.26	406.27	217.67
17.92	645.29	23.58	1484.03	111.64	434.82	623.18	734.82	300	188.36	3.31	0.26	405.77	217.41
18.14	646.94	23.87	1489.68	111.40	434.28	622.88	734.28	300	188.60	3.30	0.26	405.74	217.14
18.30	648.19	24.08	1493.81	112.58	433.92	621.33	733.92	300	187.42	3.32	0.26	404.38	216.96
18.52	649.84	24.37	1499.53	112.35	433.37	621.01	733.37	300	187.65	3.31	0.26	404.33	216.68
18.74	651.50	24.66	1505.29	112.35	432.81	620.46	732.81	300	187.65	3.31	0.26	404.05	216.40
18.91	652.74	24.88	1509.77	112.11	432.34	620.23	732.34	300	187.89	3.30	0.26	404.06	216.17
19.13	654.40	25.17	1515.61	112.11	431.77	619.66	731.77	300	187.89	3.30	0.26	403.77	215.89
19.35	656.24	25.46	1521.50	112.58	431.31	618.73	731.31	300	187.42	3.30	0.26	403.07	215.65
19.57	657.71	25.75	1527.43	112.58	430.60	618.02	730.60	300	187.42	3.30	0.26	402.72	215.30
19.73	658.95	25.96	1531.77	112.58	430.19	617.61	730.19	300	187.42	3.30	0.26	402.51	215.09
19.95	661.16	26.25	1537.78	112.58	429.94	617.36	729.94	300	187.42	3.29	0.26	402.39	214.97
20.17	662.26	26.54	1543.84	113.53	428.97	615.44	728.97	300	186.47	3.30	0.26	400.96	214.48
20.35	663.50	26.78	1548.84	113.05	428.39	615.34	728.39	300	186.95	3.29	0.26	401.14	214.19
20.56	665.16	27.05	1554.70	112.58	427.84	615.26	727.84	300	187.42	3.28	0.26	401.34	213.92

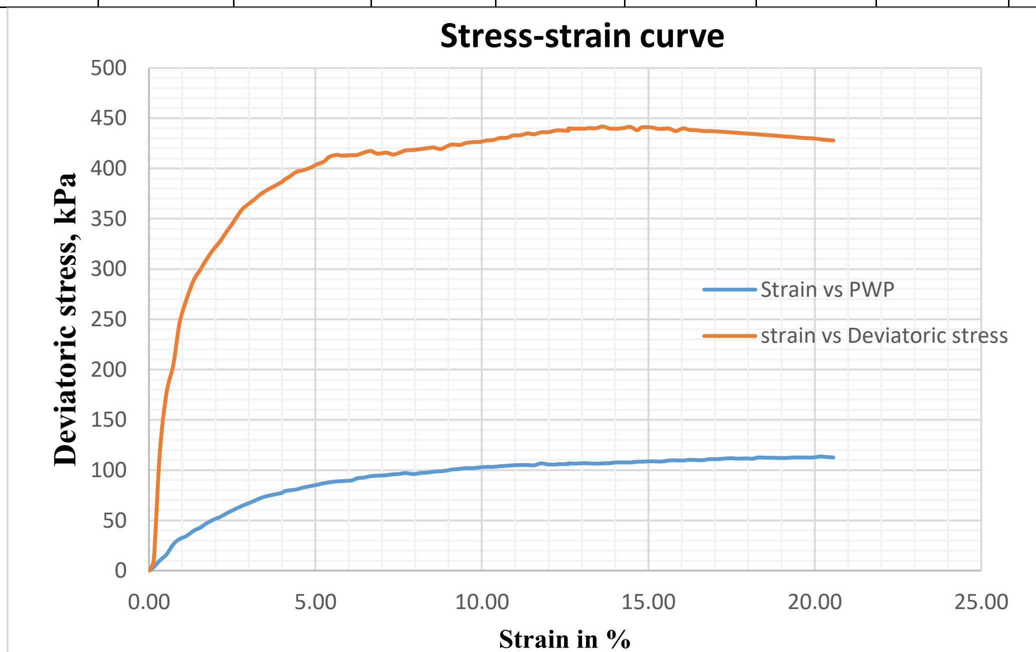


Fig.C.23. Stress-strain curves for Effective consolidation pressure of 300 kPa and strain rate of 1mm/min

Table C16.Compression stage result for 400 kPa effective consolidation pressure

Location	Asela kebele 09 (chigign mefelfeya area	Job reference	thesis research
soil Description	red brown clay	Pit number	1
Test method	CU with measurement of pore water pressure; BS 1377: clause 8	sample no	1
		depth	3.00m
Area in mm2: 1134.11	strain rate(mm/min): 1.00	Effective stress (kPa)	400

Axial Disp. (mm)	Change in force (N)	Axial Strain (%)	Area Corrected (mm2)	Change in pore pr. (kPa)	Deviator stress (kPa)	Principle stresses: Major (□1') (kPa)	major(σ 1) (kPa)	minor (σ3) kPa	Minor (□3') (kPa)	□1'/□3' (-)'	Coefficient A (-)	Stress path parameters: s' (kPa)	T (kPa)
0.00	0.00	0.00	1134.11	0.00	0.00	400.00	400.00	400	400.00	1.00	-	400.00	0.00
0.14	15.12	0.18	1136.21	5.09	13.31	408.22	413.31	400	394.91	1.03	0.38	401.57	6.66
0.36	202.90	0.47	1139.51	13.52	178.06	564.53	578.06	400	386.48	1.46	0.08	475.50	89.03
0.48	263.70	0.63	1141.32	29.81	231.05	601.24	631.05	400	370.19	1.62	0.13	485.72	115.52
0.72	334.76	0.95	1144.96	35.31	292.38	657.07	692.38	400	364.69	1.80	0.12	510.88	146.19
0.92	368.30	1.21	1148.01	41.44	320.82	679.38	720.82	400	358.56	1.89	0.13	518.97	160.41
1.12	392.11	1.47	1151.08	47.69	340.65	692.96	740.65	400	352.31	1.97	0.14	522.63	170.32
1.32	408.26	1.74	1154.16	52.27	353.73	701.45	753.73	400	347.73	2.02	0.15	524.59	176.86
1.52	424.41	2.00	1157.26	56.71	366.74	710.03	766.74	400	343.29	2.07	0.15	526.66	183.37
1.72	435.67	2.26	1160.38	59.63	375.45	715.83	775.45	400	340.37	2.10	0.16	528.10	187.73
1.92	445.57	2.53	1163.51	64.42	382.96	718.54	782.96	400	335.58	2.14	0.17	527.06	191.48
2.05	458.92	2.70	1165.55	67.53	393.74	726.21	793.74	400	332.47	2.18	0.17	529.34	196.87
2.23	464.58	2.93	1168.40	71.89	397.62	725.73	797.62	400	328.11	2.21	0.18	526.92	198.81
2.43	479.38	3.20	1171.57	77.14	409.17	732.03	809.17	400	322.86	2.27	0.19	527.44	204.59
2.70	494.21	3.55	1175.89	83.31	420.28	736.98	820.28	400	316.69	2.33	0.20	526.84	210.14
2.91	499.88	3.83	1179.27	86.76	423.89	737.14	823.89	400	313.24	2.35	0.20	525.19	211.95
3.14	509.16	4.13	1182.99	89.14	430.40	741.27	830.40	400	310.86	2.38	0.21	526.06	215.20
3.32	514.85	4.37	1185.92	92.75	434.14	741.39	834.14	400	307.25	2.41	0.21	524.32	217.07
3.53	523.38	4.64	1189.36	94.02	440.05	746.03	840.05	400	305.98	2.44	0.21	526.00	220.03
4.03	543.98	5.30	1197.62	101.22	454.22	753.00	854.22	400	298.78	2.52	0.22	525.89	227.11
4.32	551.13	5.68	1202.47	102.30	458.33	756.03	858.33	400	297.70	2.54	0.22	526.86	229.16

4.55	556.19	5.99	1206.34	105.18	461.05	755.87	861.05	400	294.82	2.56	0.23	525.34	230.53
4.74	565.35	6.24	1209.55	106.62	467.40	760.78	867.40	400	293.38	2.59	0.23	527.08	233.70
4.94	564.78	6.50	1212.96	109.14	465.62	756.48	865.62	400	290.86	2.60	0.23	523.67	232.81
5.16	573.33	6.79	1216.72	111.66	471.21	759.55	871.21	400	288.34	2.63	0.24	523.95	235.61
5.32	576.98	7.00	1219.48	114.18	473.14	758.95	873.14	400	285.82	2.66	0.24	522.39	236.57
5.58	584.16	7.34	1223.98	116.34	477.26	760.92	877.26	400	283.66	2.68	0.24	522.29	238.63
5.76	588.46	7.58	1227.12	117.79	479.55	761.76	879.55	400	282.21	2.70	0.25	521.99	239.77
5.94	592.10	7.82	1230.27	119.95	481.28	761.33	881.28	400	280.05	2.72	0.25	520.69	240.64
6.14	592.28	8.08	1233.79	122.83	480.05	757.22	880.05	400	277.17	2.73	0.26	517.19	240.02
6.36	595.22	8.37	1237.69	123.55	480.91	757.37	880.91	400	276.45	2.74	0.26	516.91	240.46
6.56	598.88	8.63	1241.25	126.07	482.48	756.41	882.48	400	273.93	2.76	0.26	515.17	241.24
6.76	603.93	8.89	1244.84	126.43	485.15	758.72	885.15	400	273.57	2.77	0.26	516.15	242.57
6.97	605.49	9.17	1248.63	128.59	484.92	756.34	884.92	400	271.41	2.79	0.27	513.87	242.46
7.17	610.19	9.43	1252.26	130.39	487.27	756.88	887.27	400	269.61	2.81	0.27	513.24	243.64
7.36	612.96	9.68	1255.72	130.39	488.13	757.74	888.13	400	269.61	2.81	0.27	513.67	244.07
7.54	614.16	9.92	1259.02	131.83	487.80	755.98	887.80	400	268.17	2.82	0.27	512.07	243.90
7.79	617.38	10.25	1263.64	131.47	488.57	757.10	888.57	400	268.53	2.82	0.27	512.82	244.28
7.95	621.18	10.46	1266.61	132.91	490.43	757.52	890.43	400	267.09	2.84	0.27	512.30	245.22
8.21	624.26	10.80	1271.47	133.99	490.97	756.98	890.97	400	266.01	2.85	0.27	511.50	245.49
8.40	626.97	11.05	1275.04	134.71	491.73	757.02	891.73	400	265.29	2.85	0.27	511.16	245.86
8.60	629.63	11.32	1278.82	135.79	492.35	756.56	892.35	400	264.21	2.86	0.28	510.38	246.18
8.79	632.96	11.57	1282.44	137.60	493.56	755.96	893.56	400	262.40	2.88	0.28	509.18	246.78
9.05	638.07	11.91	1287.42	136.87	495.62	758.75	895.62	400	263.13	2.88	0.28	510.94	247.81
9.19	641.00	12.09	1290.12	137.95	496.85	758.90	896.85	400	262.05	2.90	0.28	510.47	248.43
9.45	645.00	12.43	1295.16	137.60	498.01	760.42	898.01	400	262.40	2.90	0.28	511.41	249.01
9.66	647.90	12.71	1299.26	138.67	498.67	760.00	898.67	400	261.33	2.91	0.28	510.66	249.34
9.85	652.13	12.96	1302.99	139.03	500.49	761.46	900.49	400	260.97	2.92	0.28	511.21	250.24
10.03	654.86	13.20	1306.54	140.12	501.21	761.10	901.21	400	259.88	2.93	0.28	510.49	250.61
10.22	660.61	13.45	1310.32	139.40	504.16	764.76	904.16	400	260.60	2.93	0.28	512.68	252.08
10.41	662.04	13.70	1314.11	140.47	503.79	763.32	903.79	400	259.53	2.94	0.28	511.42	251.90
10.60	668.10	13.95	1317.93	140.12	506.93	766.82	906.93	400	259.88	2.95	0.28	513.35	253.47
10.80	670.39	14.21	1321.97	141.19	507.11	765.92	907.11	400	258.81	2.96	0.28	512.36	253.55
11.06	674.04	14.55	1327.27	142.63	507.84	765.21	907.84	400	257.37	2.97	0.28	511.29	253.92
11.25	678.56	14.80	1331.16	143.35	509.75	766.39	909.75	400	256.65	2.99	0.28	511.52	254.87
11.45	679.55	15.07	1335.29	143.35	508.92	765.56	908.92	400	256.65	2.98	0.28	511.10	254.46

11.64	681.91	15.32	1339.23	142.63	509.18	766.56	909.18	400	257.37	2.98	0.28	511.96	254.59
11.84	684.42	15.58	1343.40	143.71	509.46	765.75	909.46	400	256.29	2.99	0.28	511.02	254.73
12.03	688.30	15.83	1347.39	142.27	510.84	768.57	910.84	400	257.73	2.98	0.28	513.15	255.42
12.23	691.45	16.09	1351.62	143.35	511.57	768.22	911.57	400	256.65	2.99	0.28	512.43	255.79
12.42	692.42	16.34	1355.66	144.79	510.76	765.97	910.76	400	255.21	3.00	0.28	510.59	255.38
12.62	695.62	16.61	1359.94	144.79	511.51	766.72	911.51	400	255.21	3.00	0.28	510.97	255.76
12.81	698.22	16.86	1364.02	144.79	511.89	767.10	911.89	400	255.21	3.01	0.28	511.15	255.94
13.01	697.65	17.12	1368.36	146.23	509.85	763.61	909.85	400	253.77	3.01	0.29	508.69	254.92
13.27	703.09	17.46	1374.03	145.52	511.70	766.18	911.70	400	254.48	3.01	0.28	510.33	255.85
13.46	708.49	17.71	1378.20	145.88	514.07	768.19	914.07	400	254.12	3.02	0.28	511.16	257.03
13.66	711.04	17.97	1382.62	146.23	514.27	768.04	914.27	400	253.77	3.03	0.28	510.90	257.13
13.85	713.56	18.22	1386.85	145.52	514.52	769.00	914.52	400	254.48	3.02	0.28	511.74	257.26
14.11	718.24	18.57	1392.68	147.67	515.73	768.06	915.73	400	252.33	3.04	0.29	510.20	257.86
14.31	717.81	18.83	1397.19	146.95	513.75	766.80	913.75	400	253.05	3.03	0.29	509.93	256.88
14.50	724.22	19.08	1401.51	147.67	516.75	769.08	916.75	400	252.33	3.05	0.29	510.70	258.37
14.70	725.35	19.34	1406.08	147.67	515.86	768.19	915.86	400	252.33	3.04	0.29	510.26	257.93
14.96	725.14	19.68	1412.07	148.40	513.53	765.14	913.53	400	251.60	3.04	0.29	508.37	256.77
15.15	728.74	19.93	1416.48	149.11	514.47	765.36	914.47	400	250.89	3.05	0.29	508.12	257.24
15.35	733.14	20.20	1421.15	149.47	515.88	766.40	915.88	400	250.53	3.06	0.29	508.47	257.94
15.54	734.47	20.45	1425.62	148.04	515.20	767.16	915.20	400	251.96	3.04	0.29	509.56	257.60
15.74	735.09	20.71	1430.35	149.83	513.92	764.09	913.92	400	250.17	3.05	0.29	507.13	256.96
15.93	735.67	20.96	1434.87	149.47	512.71	763.23	912.71	400	250.53	3.05	0.29	506.88	256.35
16.13	739.28	21.22	1439.66	148.75	513.51	764.76	913.51	400	251.25	3.04	0.29	508.00	256.76
16.32	739.86	21.47	1444.25	149.84	512.28	762.44	912.28	400	250.16	3.05	0.29	506.30	256.14
16.45	740.28	21.64	1447.40	149.90	511.45	761.56	911.45	400	250.10	3.04	0.29	505.83	255.73

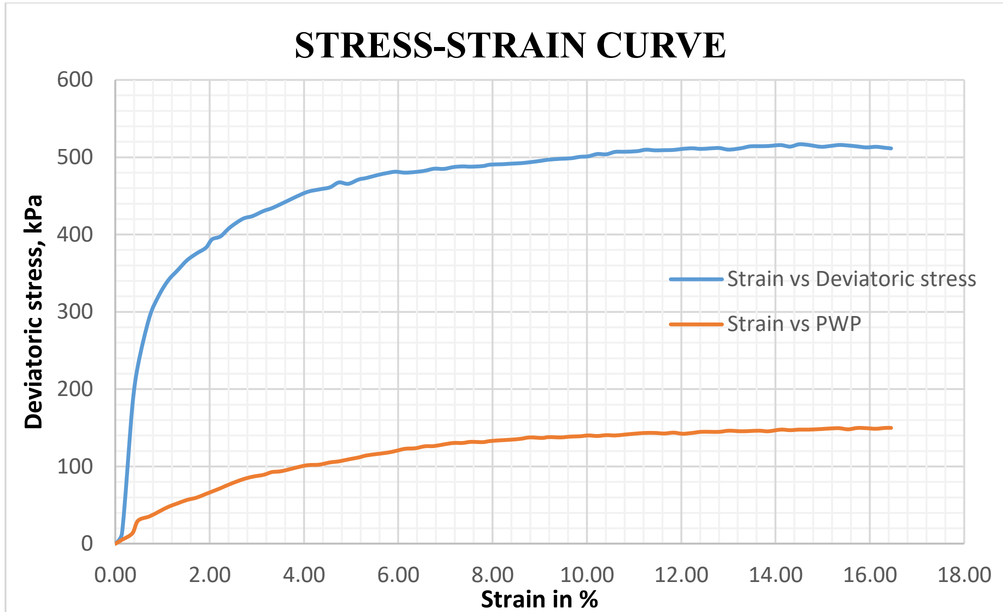


Fig.C.24. Stress-strain curves for Effective consolidation pressure of 400 kPa and strain rate of 1mm/min

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