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FRICTIONAL RESISTANCE BETWEEN ORGANIC SOIL AND CONSTRUCTION MATERIALS

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Frictional Resistance Between Organic Soil And Construction Materials

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Supervisor

Assoc. Prof. Dr. Hanifi ÇANAKÇI

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ABSTRACT

FRICTIONAL RESISTANCE BETWEEN ORGANIC SOIL AND CONSTRUCTION MATERIALS

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Organic soil is a mixture of fragmented organic material formed in wetlands under appropriate climatic and topographic conditions and it is derived from vegetation that has been chemically changed and fossilized. This type of soils has low shear strength and high compressive deformation which often result in difficulties when construction work is undertaken on the deposit.

In this study, interface friction between organic soil and some of construction material used in pile foundation was investigated. Construction materials used in this work are rough and smooth concrete, corrugated and painted metal, and wood. Soil used in this experiment was obtained from Sakarya region, Turkey. Four different water contents were used for organic soils. These are %0, %25, %50 and 75%. Interface friction angle was measured using direct shear test device. Tests were performed with locating construction material at lower part of the shear box and filling the upper part with organic soil. Three different normal forces were used 5kg, 10kg, 20 kg and shear stress at 5% strain rate was taken as maximum shear stress to determine interface friction angle.

Test results showed that water content of the organic soil, surface roughness and material type effect interface frictional coefficient.

Key Words: organic soil, construction materials, shears strength, friction resistance, direct shear test.

ÖZET

ORGANİK ZEMİNİN BAZI YAPI MALZEMELERİ İLE SÜRTÜNME MUKAVEMETİ

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Organik toprak, uygun iklim ve topoğrafik koşullar altında sulak alanlarda oluşan parçalanmış organik madde karışımı olup, zamanla kimyasal olarak değişerek fosilleşmiş bitki örtüsüdür. Bu tür zeminler düşük kayma mukavemetine ve yüksek sıkışma özelliklerinden dolayı üzerlerine yapı inşaa edilmesi durumunda problem oluşturmaktadırlar.

Bu çalışmada, organik toprak ile kazıklı temel yapımında kullanılan ahşap, metal ve beton arasındaki arayüzey sürtünme açısı araştırırdı. Deneyde kullanılan organic zemin Sakarya bölgesinden temin edildi. Çalışmada dört farklı su içeriği kullanıldı. Bunlar 0%, 25%, 50% ve 75%. Arayüzey sürtünme açısı direkt kesme deney cihazı kullanılarak hesaplandı. Testler, kesme kutusunun alt kısmına inşaat malzemesi konulup üst kısmına organik toprak sıkıştırılarak yapıldı. Herbir malzeme için deneyler üç farklı normal kuvvet altında, 5 kg, 10 kg ve 20 kg, tekrarlanarak %5 deformasyon anındaki kayma gerilmesi maksimum kayma mukaveti olarak alınıp arayüzey sürtünme açısı hesaplandı..

Sonuçta organik zeminle inşaat melzemeleri arasındaki arayüzey sürtünme açısının organik toprağın su muhtevasına, malzemenin cinsine ve pürüzlülüğüne bağlı olarak değiştiği gözlendi.

Anahtar Kelimeler: organik zemin, yapı malzemeleri, kesme dayanımı, sürtünme kuvveti, direk kesme deneyi.

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CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF SYMBOLS

A Cross sectional area of specimen in shear box test

CD Consolidated drained test

c_u Undrained shear strength

C_f Function of clay content

c' Cohesion intercept in terms of effective stresses

c Cohesion intercept in terms of total stresses

D_r Relative density

d Diameter

e Overall void ratio of soil

e_0 Initial void ratio

e_{cv} Critical void ratio

e_{max} Maximum void ratio

e_{sk} Skeleton void ratio

f Ratio of weight of fines to total weight of solids

h Height

I_p Plasticity index

LL Liquid limit

N Normal load

N_{60} SPT blow count corrected for field procedures

OCR Over consolidation ratio

P_h Horizontal load

PI Plasticity index

P_v Vertical load

s_u Undrained shear strength

T Maximum torque

UU Unconsolidated undrained

u Pore water pressure

ψ Angle of dilation

ε_v Vertical strain

ϕ Friction angle in terms of total stresses

ϕ' Friction angle in terms of effective stresses

ϕ'_{max} Maximum angle of shearing resistance

ϕ'_{cv} Critical angle of shearing resistance

ϕ'_u True angle of friction

λ Unit weight

σ_f Normal stress on failure plane

σ' Effective normal stress

σ'_3 Effective minor principal stress in triaxial test

τ Shear stress in shear box test and drained shear strength

τ_f Shear stress on the failure plane

τ_u Undrained shear strength

CHAPTER 1

INTRODUCTION

In geotechnical engineering, there are so many problems with ground during building a structure. The main problems are bearing capacity, lateral earth pressure, settlement, and slope stability.

Organic soils and peat were believed to be geotechnically problematic due to their very high compressibility, very low shear strength and difficult accessibility. Although conventional soil mechanics theory could be applied to the soils, it was found that important anomalies existed which required special considerations. Geomechanical parameters for the soils were known to be important for geotechnical engineers to be able to obtain suitable design parameters, as well as to find suitable construction techniques on these soft materials.

Organic soils are occured by mixture of fragmented organic material formed in wetlands under suitable climatic and topographic conditions and they are formed from vegetation that has been chemically changed and fossilized. This types of soil generally formed in thick layers in limited areas, is geotechnicaly problematic due to their very high compressibility and very low shear strength. Because it includes huge amount of organic content represent the extreme form of soft soil.The physical properties of organic soils are dependent on the four major components which make up the organic soil system; the organic material, the mineral material, water and air. Andriesse (1988) highlighted difficulties in characterisation of the physical properties of organic soils caused by the changes in the proportions of the four components upon reclamation or drainage for utilisation.

Organic soil at a construction site is not always completely useful for constructing structures for instance buildings, bridges, highways and dams. In organic soil, there is usually large consolidation settlement depending on depth of layer and structural load. Under these problems, soils needs ground modification such as reducing consolidation and elastic settlement and increasing shear strength of organic soils. If it is possible, the problematic organic soils must be removed and replace with better soil at site. If not possible different modification techniques need to be used such as hydraulic modification, inclusion, chemical modification, compaction, mixing pile foundation.

Many soil-structure interaction problems including retaining walls, pile foundations and earth reinforcements involve the estimation of interfacial friction between soils and such structures. It is essential to determine the interface friction angle between soil and pile material in order to make a good estimation of the axial capacity of the pile.

In this thesis, it was aimed to determine angle of friction of organic soil with inclusion of steel, timber, concrete, rough concrete, rough steel, painted steel. Six different experimental programs are thought to be conducted using direct shear testing.

CHAPTER 2

LITERATURE SURVAY

2.1. Introduction

Many soil-structure interaction problems including retaining walls, pile foundations and earth reinforcements involve the estimation of interfacial friction between soils and such structures. It is essential to determine the interface friction angle between soil and pile material in order to make a good estimation of the designed structures. A limited review of previous work on interfacial friction between sand and other materials is provided below.

Considerable studies have been done to investigate the interfacial friction between sand and various construction materials. Several kinds of apparatus were used in the literature such as direct shear test apparatus (Potyondy 1961, Acar et. al. 1982, Bosscher and Ortiz 1987, O'Rouke et. al 1990, Subba et. al 1988 and Reddy et. al 2000), simple shear apparatus (Uesugi and Kishida 1986, Kishida and Uesugi, 1987), ring torsion apparatus (Yoshimi and Kishida 1981) and dual shear apparatus (Paikowsky et. al 1995). Miniature pile test apparatus (Coyle and Sulaiman 1967) and soil-pileslip tests apparatus (Reddy et. al 1998) have also been used for this purpose. Several factors affecting the value of the interface friction angle were investigated. Among those factors are: (i) soil properties such as mineralogical composition, density, grain shape, grain size and gradation; and (ii) the properties of the material surface such as hardness and surface roughness.

Early systematic efforts to obtain data on the behavior of soil-to-structure interfaces were carried out by Potyondy (1961), Clough and Duncan (1971), and Peterson et al. (1976), among others. Their tests were performed using a slightly modified Direct Shear Box (DSB) in which a concrete specimen occupied one of the halves of the shear box. In most cases, the soil sample was prepared against a concrete specimen situated at the bottom. The tests were typically performed by first increasing the normal pressure to a desired value, then shearing the interface under constant normal stress to a maximum displacement of about 12.5 mm.

Peterson et al. (1976) studied the fundamental factors that influence interface behavior. They performed a large number of sand-to-concrete interface tests using a 102- by 102-mm (4- by 4 in.) DSB. In their tests, the interface was inundated and sheared, under drained conditions and constant normal load, to a maximum displacement of 12.5 mm (0.5 in.). They analyzed the influence of normal stress, interface roughness, and soil characteristics on interface behavior, and developed a database of sand-to-concrete interface friction angles.

Shakir and Zho (2009) studied interface properties between compacted clay and concrete were conducted systematically using interface simple shear test apparatus. They used samples, having same dry density with different water content ratio and two types of concrete with different surface roughness, i.e., relatively smooth and relatively rough surface roughness, were also prepared. The main objectives of their work is to show the effect of water content, normal stress and rough surface on the shear stress-shear displacement relationship of clay-concrete interface. They found following results: 1) the interface shear sliding dominates the interface shear displacement behavior for both cases of relatively rough and smooth concrete surface except when the clay water content is greater than 16% for the case of rough concrete surface where the shear failure occurs in the body of the clay sample; 2) the results of interface shear strength obtained by direct shear test were different from that of simple shear test for the case of rough concrete surface; 3) two types of interface failure mechanism may change each other with different water content ratio; 4) the interface shear strength increases with increasing water content ratio especially for the case of clay-rough concrete surface interface.

Gouhari and Roohimehr stduied the effects of surface roughness on the unit shaft resistance of piles embedded in a dry natural fine sand mass, a research program comprising 25 axial loading tests was carried out on 44 mm diameter model piles with different surface roughness. In order to provide piles with different surface roughness they were wrapped with sandpapers with different grits. Their test results indicate that when the average abrasive particles size of sandpapers varies from 18.3 to 425 microns, the lateral earth pressure coefficient increases from 0.95 to 1.75. This implies that pile surface roughness enhances the tendency of the sand to dilate during loading, which increases magnitude of the radial effective stress against the pile surface. Also, it was disclosed that when the average abrasive particles size of sandpapers varies from 18.3 to 425 microns, the unit shaft resistance increases from 2.5 to 9.1 kPa. These results indicate that the pile shaft resistance increases due partially to the fact that the sand mass-sand paper interface friction angle increases as the sand paper roughness increases.

It is discussed in this paper that the results of a series of direct shear test that were undertaken to investigate the behavior of organic soil incorporated with construction materials. The tests focused on studying the effect of varying the water content and different construction materials.

CHAPTER 3

EXPERIMENTAL STUDY

3.1 Direct Shear Test

The direct shear test is a strain-controlled test: the rate at which the soil will be strained is controlled. A specimen of soil will be placed into a shear box, and consolidated under an applied normal load. The shear box is made of two separate halves, an upper and a lower. After the application of the normal load, these two halves of the be moved relative to one another, shearing the soil specimen on the plane that is the separation of the two halves. The direct-shear test imposes stress conditions on the soil that force the failure plane to occur at a predetermined location (on the plane that separates the two halves of the box).On this plane there are two forces (or stresses) acting- a normal stress, σn, due to an applied vertical load Pv and a shearing stress, τ, due to the applied horizontal load Ph. These stresses are simply computed as:

$$\sigma n = Pv/A \quad (3.1)$$

$$\tau = Ph/A \quad (3.2)$$

where A is the nominal area of the specimen (or of the shear box). It is usually not corrected for the change in sample area caused by the lateral displacement of the sample under the shear load Ph.These stresses should satisfy Coulomb's equation:

$$\tau = c + \sigma n \tan\varphi \quad (3.3)$$

As there are two unknown quantities (c and φ) in the above equation, two values, as a minimum, of normal stress and shear stress will be required to obtain a solution. Since the shear stress and normal stress have the same significance as when used in a Mohr's circle construction, rather than solving a series of simultaneous equations for c and tanφ, one may plot on a set of coordinate axes the values of t versus sn from several tests (generally with τ on the ordinate), draw a line through the resulting locus of points, or the average locus of points, and establish the slope of the line as $\tan\varphi$ and the τ -axis intercept as the c parameter. This is commonly known as the Mohr-Coulomb Failure Envelope.

For cohesionless soils, the intercept is usually negligible, and Coulomb's equation becomes

$$\tau = \sigma n \tan\varphi \qquad (3.4)$$

Test inaccuracies and surface-tension effects of damp cohesionless materials may give a small value of c, called the "apparent" cohesion. This should be neglected unless it is more than 1 or 2 psi. If the c value is large and the soil is a cohesionless material, the reason for the large value should be investigated.

The direct shear test was formerly quite popular, but with the development of the triaxial test which is much more flexible, it has become less popular in recent years.

The advantages of the direct shear test are:

- Cheap, fast and simple - especially for sands.
- Failure occurs along a single surface, which approximates observed slips or shear type failures in natural soils.

Disadvantages of the test include:

- Difficult or impossible to control drainage, especially for fine-grained soils.
- Failure plane is forced--may not be the weakest or most critical plane in the field
- Non-uniform stress conditions exist in the specimen.
- The principal stresses rotate during shear, and the rotation cannot be controlled.
- Cannot control pore pressures. Therefore tests are assumed to be drained.
- Failure on horizontal plane only, which may not be the weakest plane.
- Non-uniform stress conditions inside shear box.
- Principal stress rotations occur
- Vertical and horizontal stresses are principal stresses before shear.
- Vertical and horizontal stresses are not principal stresses at failure.

Principal stresses are not directly measured. Because the drainage conditions during all stages of the test markedly influence the shear strength of soils, the direct shear test is only applicable for relatively clean sands which are free draining during shear. For clay soils, some unknown amount of consolidation could occur during shear, which would give a larger shear strength than actual. Therefore the test is not generally recommended for cohesive soils.

3.2. Procedure

Each group will perform one direct shear test, each at a specified (unique) normal load. The three groups in each section will then share their data, in order to plot the Mohr-Coulomb Failure Envelope (there will thus be three points on this plot). Because the three groups in each section will be sharing data, it is imperative that each group set up its specimen at the same density as all other groups. This density will be specified by the instructor.

1.Become familiar with the apparatus, see figure 3.1 below.

Figure 3.1 Direct Shear Test Apparatus

In particular:

- How to apply normal loads (the pressure indicator, the calibration curve, the belofram valve, the regulator).
- The function of each screw in the shear box.
- The measurement the dial indicators are taking (what's it measuring, what are the units, which direction will it move?)
- The direction of travel of all parts of the apparatus
- The electric motor (on/off switch, forward/reverse, speed), determine which direction is forward and reverse on the motor before assembling specimen, Figure 3.2. below

Figure 3.2 Motor and Motor Control Panel of Direct Shear Test

2. Determine the volume of the specimen to be constructed**.**

- Using the fixing screws, lock the two halves of the shear box together see figure 3.3 below.
- Measure the cross-sectional area of the interior of the shear box.
- Measure the depth of the shear box.
- Determine the thickness of the bottom frictional plate and the top porous stone

Figure 3.3 The Shear Box

When the specimen is setup, the frictional plate will be at the bottom of the shear box. Sand will then be placed on top of this, and on top of the sand will be a porous stone. When this is all set up properly, the top of the porous stone should be flush with the top of the shear box. Knowing this, and with the above dimensions measured, the volume of the prepared specimen may be calculated.

3. Knowing the density desired and the volume of the specimen, calculate the mass of sand required to set up the specimen.

4. Obtain the required mass of sand.

5. Set up the specimen.

- Place the shear box in the direct shear device.
- Make sure the fixing screws (screws that locks the shear box together) are locked in place and the set screws (screws that adjust the gap space between the shear box halves) are at the bottom of their travel.
- Place the bottom frictional plate into the bottom of the shear box with the rough side up.
- Pour the sand in rather loosely.
- Place the porous stone on top of the sand. It should be sticking up out of the shear box at this point, see Figure 3.4 below.

Figure 3.4 The Shear Box

- Tap on the shear box to densify the sand until the top porous stone becomes flush with the top of the shear box. You now have a specimen of sand placed at a known density.
- This may take several attempts to get it just right. Be patient.

6. Place the loading cap and ball bearing on top of the porous stone.

7. Lower the reaction bar of the pneumatic loading frame until it just touches the ball bearing.

8. Use the nuts to lock the reaction bar into place.

9. Remove the fixing screws.

10. Adjust all dial gages. Take initial readings at this time.

11. Use the calibration curve to determine the applied air pressure to achieve the desired normal pressure.

12. Close the belofram check valve and the blow-off valve,

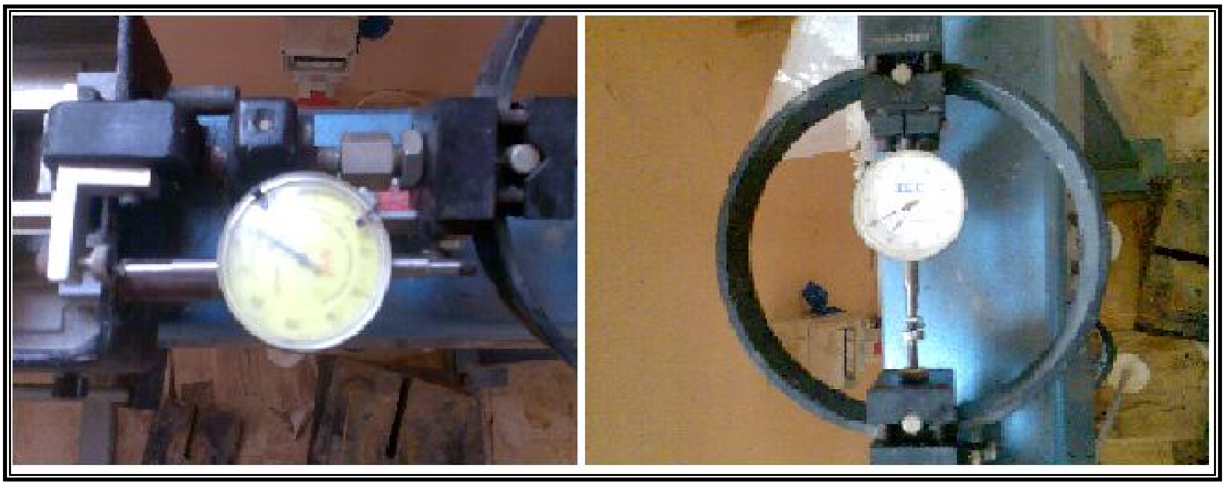

Figure 3.5 Dialgages of Horizontal Displacement and Vertical Force

13. Adjust the regulator to the desired air pressure. Do not exceed the indicated limit.

14. Open the check valve.

15. Record the new vertical displacement dial reading. It will have moved, and the specimen will thus have densified. This combined with the initial dial reading you already obtained will allow you to calculate the actual density of the specimen (it will be slightly denser than planned).

16. Adjust the set screws. Starting with the set screws at the bottom, turn each ¾ turn clockwise. This will separate the two halve of the shear box. This separation should be slightly smaller than the largest grains of soil in the sample.

17. Shear the specimen.

- Start the horizontal (shear) loading and take readings of the load, shear displacement, and vertical displacement dials. Take readings every 0.01inches of shear (horizontal) deflection—this corresponds to every 10 unitson the dial.
- The shearing is complete when load is determined to be dropping (the residual strength of the soil has been reached).

18. Back off the applied normal pressure, dismantle and clean the shear box.

3.3. Calculations

1. Compute the shear stress as

$$\tau = Ph / A \qquad (3.5)$$

2. Compute the normal stress as

$$\sigma n = Pv / A \qquad (3.6)$$

3. Compute the horizontal displacement, dh, and the vertical displacement, dv, for each observed value.

4. Plot shearing stress against horizontal displacement and obtain the maximum value of shearing stress, tmax.

5. Plot a graph of normal displacement vs. shear displacement. This should be on the same page (same horizontal scale) as the shearing stress vs. shear displacement plot.

6. Using data from all three groups, plot shearing stress against normal stress and show the angle of internal friction, **φ**, and the intercept, c.

The use of this piece of equipment is to measure the effective stress parameters of c' and **φ**. The direct shear test can be run on any type of soil sample, but it is particularly adapted to cohesionless materials. This machine can also be used to establish the undrained shear strength of saturated highly plastic cohesive soils under certain conditions.

The direct shear test is normally run as a strain-controlled test, however, under certain circumstances tests can be run under stress controlled conditions. In order to obtain the effective stress parameters of any soil, excluding the most pervious medium and fine sands, it is necessary to use a slower rate of shearing in order for induced pore pressures to dissipate. The remainder of this report presents a discussion on the sample preparation for testing, equipment preparation, and running the direct shear test.

Undisturbed samples will be selected for strength testing in the usual manner. Once extruded, the samples should be trimmed carefully down to the internal diameter of the direct shear rings, in a similar manner as for consolidation test samples. When dry sand samples are to be tested, (undisturbed samples are almost impossible to obtain) the void ratio should be duplicated in the laboratory. The object is to get at least 1 inch of soil sample sandwiched between a layer of filter paper and a porous stone on either side of the sample. The porous stones provide drainage and are used to distribute the pressure during the test.

Place two porous stones on top of the soil sample to be extruded. Extrude the soil sample into the locked pair of shear rings until the top of the two stones become flush with the top of the direct shear rings. An additional 1/8 inch to 1/4 inch of soil is further extruded and the direct shear sample is separated from the field sample.

After final trimming of the sample, filter paper and porous stone are placed on each side of the soil sample, centering it within the shear rings.

The water content is determined from the remainder of the field sample. Additional data is taken as to the number of the shear ring, the soil description, and the water content. If the soil sample is to be inundated, it is first necessary to saturate the porous stone by boiling them for at least five minutes and letting them cool under deaired water.

3.4. Equipment Preparation

Prior to testing, the direct shear machine should be checked for cleanliness and proper mechanical condition. Special care should be taken to see that the roller bearings underneath the direct shear plate are properly cleaned and contain a slight amount of oil. The main loading shaft should be returned to its original starting position.

3.5. Specimen Setup in Machine

The following steps are now presented in order in which a specimen would be prepared in the direct shear machine for testing. At this time the hardened direct shear rings would be held together by three bolts and the soil specimen would be centered inside the rings. The outside faces of the soil specimen should be covered with a piece of filter paper cut to the appropriate diameter followed by a porous stone.

The shear rings with soil specimen and stones are then carefully placed inside the direct shear box. The top yoke is placed over the rings, and the entire box pushed forward towards the load ring. The restraining screw is attached finger tight. The loading shaft is positioned through the loading collar and the appropriate nut attached with a small seating load. The top transverse bar is now placed over the sample such that the bar will just rest upon the loading ball with base centered over the specimen. 'The top tightening screws are brought down until they are just finger tight. The bottom tightening screws are then brought up and tightened securely by hand. At this time a small normal seating load in the order of 100 lbs/sq. ft is placed on the soil specimen. The vertical dial indicator is positioned and set to read some arbitrary initial reading. Next, the horizontal dial indicator is attached and set at some initial reading. This sets the stage for the next phase, consolidation of the specimen with the application of the desired overburden pressure or some other normal pressure.

3.6. Test Procedure

The final dial reading after consolidation is noted on the data sheet. Adjust the anchoring nut to provide a small seating load on the sample. The horizontal dial indicator is adjusted to some convenient zero point. Until this time, the two hardened shear rings have been held together by three screws, these three connector screws are now removed.

The separating screws are now turned to force the shear rings apart at a prescribed distance depending on the soil type. For sands of a fine to medium size, 3/4 of a revolution of the set screw is used. For coarser sands, 1 revolution is used. For fine grain soils and clays, 1/3 revolution is used. These values are not absolute and can be altered accordingly.

Initial readings are taken at this time. The test is now started by the counter clockwise rotation of the loading device at the prescribed rate of shear either manually or by motor. Unless automatically recorded, the load dial and vertical deflection dial indicator will be read at various prescribed horizontal deflection readings such as every ten divisions of the three place dial until failure.

Usually the test is carried out past failure to determine the residual strength which may be used in design. At this point the test is completed and the machine is dismantled.

3.7. Specimen Removal and Cleanup

The shear loading is stopped, put into reverse, and reduced until no shear stress is on the sample. The normal pressure is now reduced. The apparatus is taken down in reverse order as assembled. The sample is extracted and weighed in order to determine the dry density and water content at failure. The machine is cleaned and the bearings are checked for dirt and are oiled and cleaned if necessary.

3.8. Computations and Report

The shear stress on the sample is easily computed by dividing the shear force as measured by the load ring or load cell by the area of the sample, uncorrected for deflection. To evaluate for the shear test, graphs of shear stress versus horizontal deflection, vertical deflection versus shear (horizontal) displacement, and a Mohr envelope are plotted. From the Mohr envelope, the effective stress parameters c' and φ ' are established.

3.9. Calibration

The calibration is to determine the deformation of the apparatus when subjected to consolidation load, so that for each normal consolidation load the apparatus deflection may be subtracted from the deformation. Therefore, only deformation due to sample consolidation will be reported for complete tests. Calibration for the equipment load-deformation characteristics need to be performed on the apparatus when first placed in service or when apparatus parts are changed.

The calibration curve for the direct shear test apparatus is as followings.All the test results were calibrated with respect to this curve.

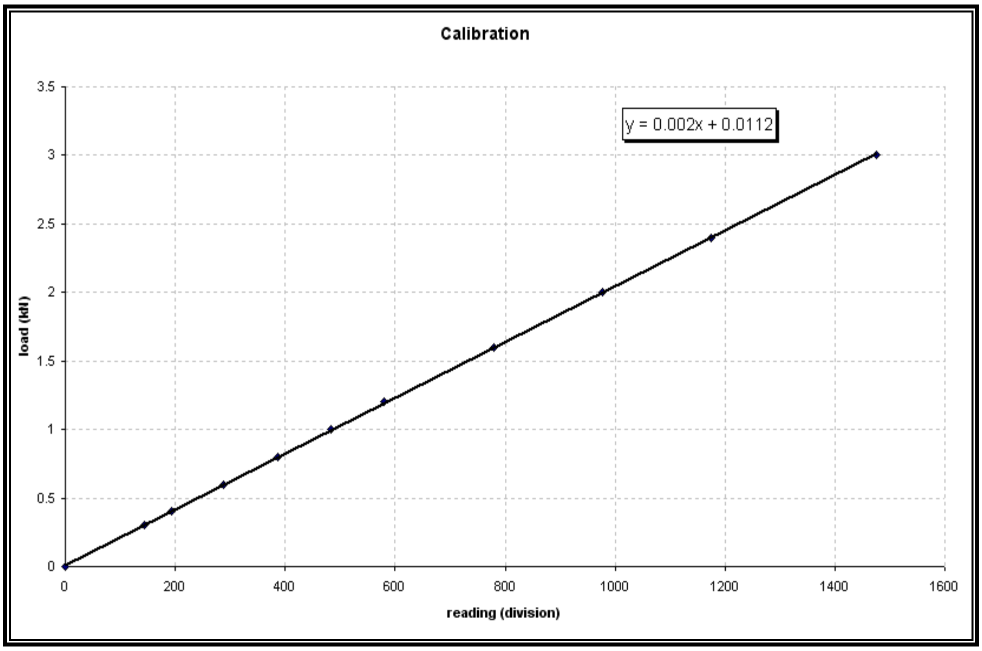

Figure 3.6 Calibration Curve

CHAPTER 4

MATERIALS AND TEST METHODS

4.1. Introduction

In this study the need for a systematic detailed study was carried out to identify the factors affecting interface friction between organic soil and timber, steel, rough steel, painted steel concrete and rough concrete surfaces. In a series of stress and strain controlled tests on timber, steel, rough steel, painted steel concrete and rough concrete steel, was tested in 60 mm and 60 mm shear box.

4.2. Construction Materials

4.2.1. Organic Soil

Peat in strict definition usually refers to the accumulation of a purely one hundred percent organic material and the distinction between soil and vegetative accumulation is not clear (Andriesse,1992). organic content of greater than 20% are generally termed organic soils. Peat is an organic soil which consists more than 75% of organic matters. The precise classification of peat however varies between soil science and engineering, as well as between countries.

The geomechanical engineering definition is essentially based on geotechnical properties of the soil. However Hobbs and Edil, suggest the important following characteristics should be included in a full description of a peat: Color, degree of humification (fibric, hemic, sapric), water content, organic content, Atterberg's consistency and fiber content. The content of peat soil differs from location to location due to the factor such as the origin fiber, temperature and humidity. These soils are geomechnically problematic due to their high compressibility and low shear strength. Hence, suitable geomechnical design parameters and construction techniques needed for this type of ground condition. This study presented correlations of engineering properties and compressibility behavior of various types of tropical peat soil from several locations in Sakarya. Engineering properties of studied organic soil is given in Table 4.1

Table 4.1 Engineering properties of the organic soil used in the study

Soil properties	Values
Organic Content (%)	50-70
PH	4,5-6,5
Organic Carbon(%)	20-30
Water keeping capacity, (in volume %)	85-95
Air capacity, (in volume %)	15-25
Easily absorbable water, (in volume %)	13-18

4.2.2 Steel

Two square plates of steel were fabricated so that they fit into the mold of the conventional direct shear test apparatus. The size of each plate was 60 mm x 60 mm x 2 mm thick (Fig.4.1. They were filled by scratch then the surface was leveled using a spatula. Three extreme surface roughnesses were used a smooth, rough and painted. Rough surface on the second plate which was glued on the timber was formed with grinder. Surface of the steel was deformed both in vertical and horizontal directions (Fig.4.2) As a result of the grinding process, anisotropic surface roughness is imparted to the specimen. 3 layers of anti rust-paint was applied on the painted steel plate and finally, this painted plate was also glued on the timber (Fig.4.3)

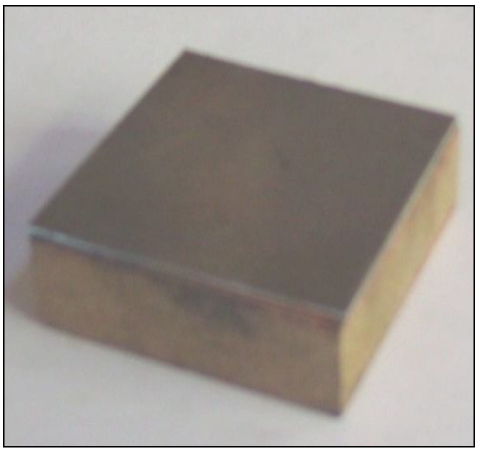

Fig. 4.1 Steel plate at the bottom part of the shear box

Fig.4.2 Rough steel plate at the bottom part of the shear box

Figure 4.3 Painted steel plate at the bottom part of the shear box

4.2.3 Concrete

Concrete structural material was prepared so that the strength value is a practical value, at the same time it can be sheared with organic soil repeatedly with minimum wear on the surface. Two boxes were manufactured as concrete mortar container. These boxes, which consist of four pieces welded to a plate at the bottom, were used to minimize the deformation during shear interface testing and were used as external reinforcement.

The concrete was prepared by first mixing the sand and cement, adding water with 60% water cement ratio and mixing gradually, subsequently filling the two boxes with concrete.

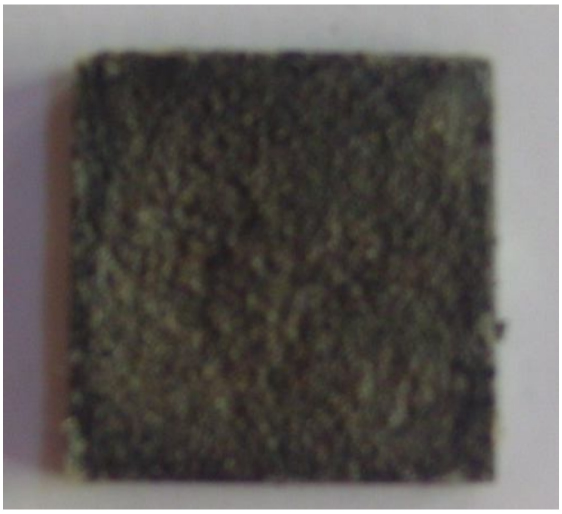

Fig.4. 4 Concrete plate at the bottom part of the shear box

Fig. 4. 5 Rough concrete plate at the bottom part of the shear box

Two different suface roughness were used, smooth and rough.Smooh surface was obtained by using spatula when the corresion wet. Spatula was movement on both direction many times to obtain smooth surface.(Fig.4.4). Rough surface was obtained by pooring fine sand on wet concree surface (Fig.4.5). The they both cored for 10 days to linear their strength. The dimension of each box is 60 mm*60 mm*20mm. They were used in the interface testing with organic soil.

4.2.4 Timber

In order to determining the timber-organic soil interface friction angle special direct shear tests were performed using pine wood sample. Size of the sample was 20 mm× 60mm × 60mm direct shear apparatus shear box. The total thickness of the wood block was so as the finished surface and upper surface of the lower platen of the shear box were exactly on same plane, where the shear plane passes through shear box. As shown in figure 4.6

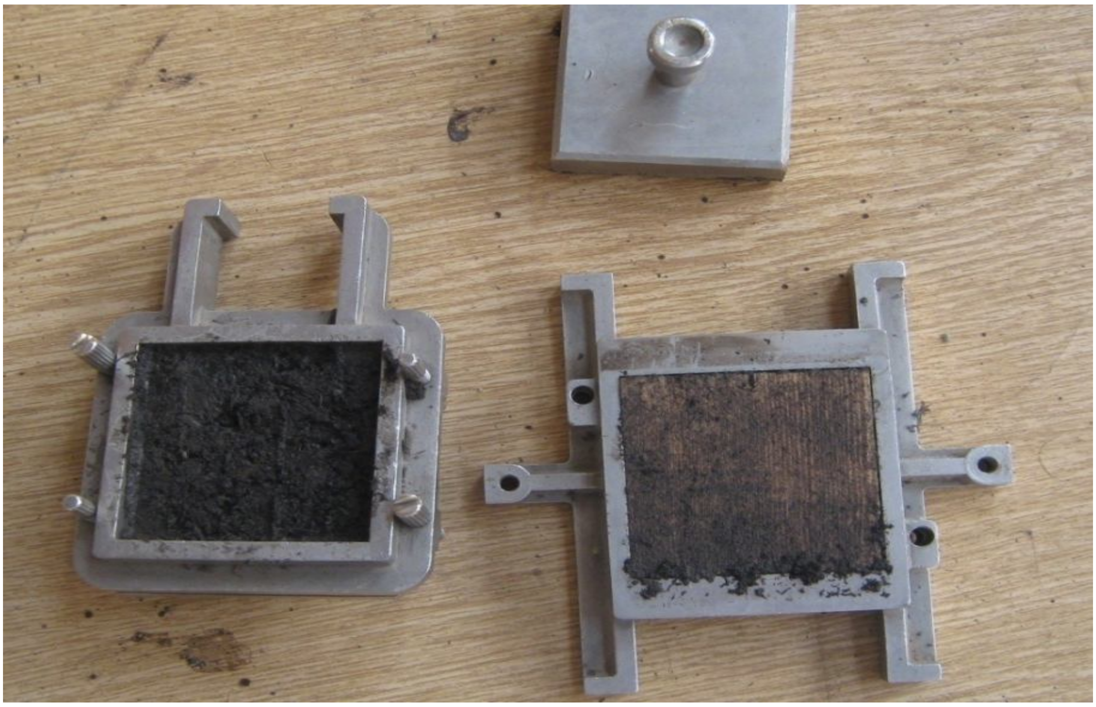

Figure 4. 6 Timber plate at the bottom part of the shear box

4.3 Test Methods

The conventional direct shear test apparatus with dimensions of 60mm x 60 mm was used in this study. For the interface tests, constrution material was placed in the lower half of the direct shear box and the upper half of the shear box was filled with organic soil at the desired density. In all tests, the unit weight of the organic soil was changed depending on moisture content. Tests were conducted with a deformation-controlled direct shear machine connected to a variable speed motor in series with a gear reduction box, which made it possible to maintain the rate of shearing at a desirable constant level. Test speed can be controlled by choosing the appropriate gear wheel from the gear box. Samples were sheared at 1.0 mm/min. For each tests three normal stress values were used. These are 30 kPa, 60 kPa and 120 kPa during the shear test, shear stress and shear displacement were measured.

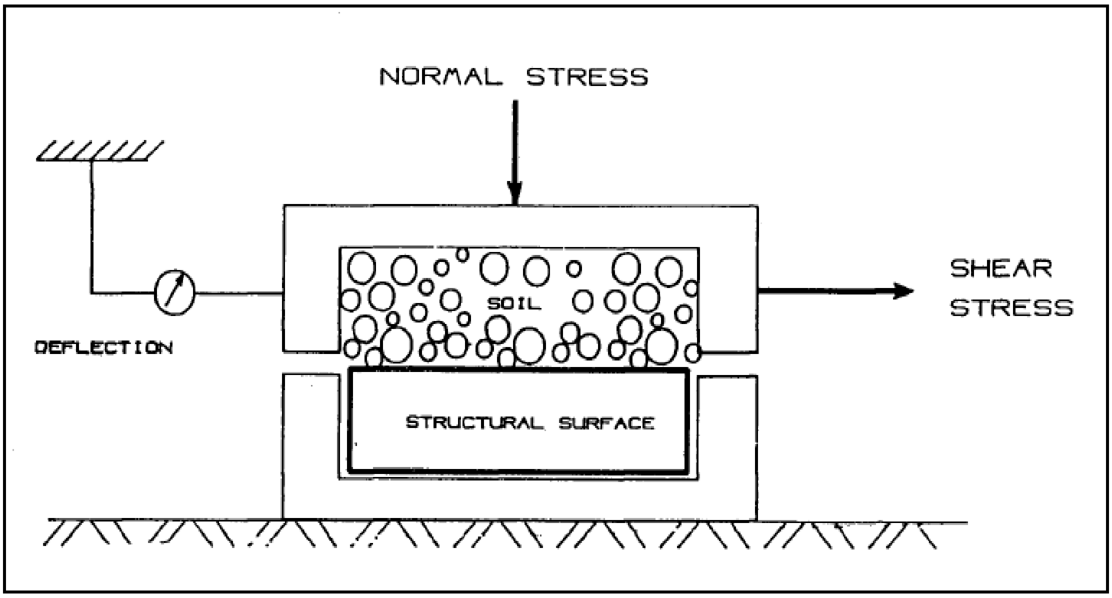

Figure 4.7 A ready sample to test

A total of fifty four interface shear tests were conducted, twelve tests on using smooth steel surface, six tests for using rough steel surface, six tests using painted steel surface, twelve tests using timber surface, twelve tests using smooth cocrete surface and the other six tests using rough concrete surface were carried out.

The test specimen was prepared inside the frame of rings by filling the container with organic soil then it was compacted by pressing method so that it has the same dry density with different water content ratio. The dry density of the organic soil is 0.486 g/cm^3 and the water content (Wc) is about 0%.

CHAPTER 5

TEST RESULT and DISCUSSION

5.1 Introduction

In this chapter we will discuss angle of friction between organic soil and construction materials in different water content. Tests were performed in different amount of water contents. Theses are %0, %25, %50 and %75. Timber, concrete, steel, rough concrete, rough steel and painted steel were used as a construction material in all tests.

A total of fifty four interface shear tests were conducted, twelve tests using smooth steel surface, six tests using rough steel surface, six tests using painted steel surface, twelve tests using timber surface, twelve tests using smooth concrete surface and the other six tests using rough concrete surface.

5.2 Interface friction between dry organic soil and test material

Interface friction angle between dry organic soil and six different interfaces were tested. Change in friction angle with material type is shown in Figure 5.1.

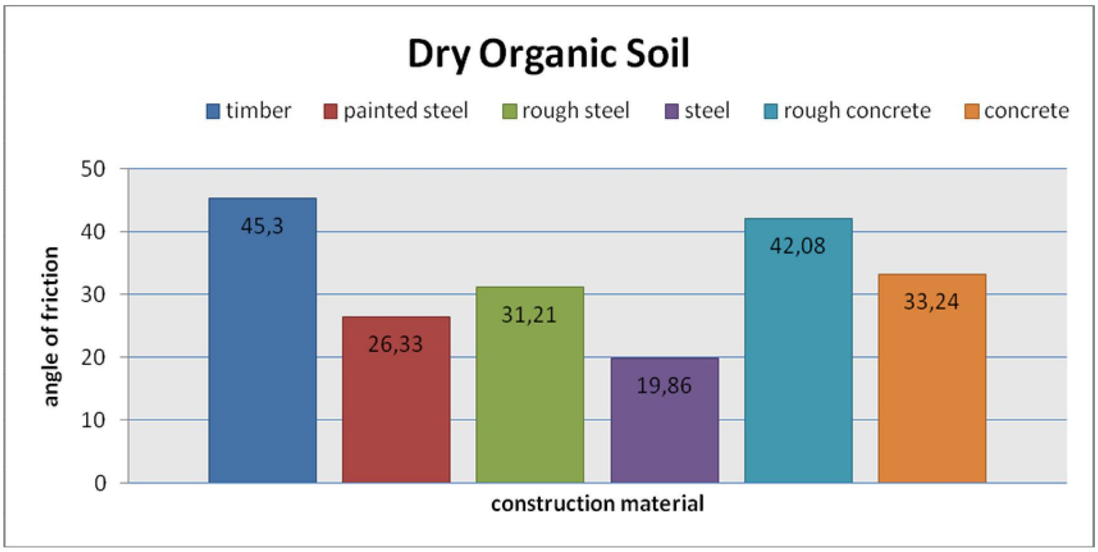

Figure 5.1 Angle of friction of construction materials for dry organic soil

As can be seen in figure 5.1 highest friction angle was obtained in timber which is 45.3 and lowest interface friction angle was obtained on smooth steel which is 19.8. Interface friction angle for painted steel, rough steel, smooth concrete and rough concrete were 26.3, 31.2, 33.24 and 42.08 respectively.

5.3 Effect of water content on interface friction angle

In order to investigate effect of water content on interface friction angle between organic soil and construction material three different water contents were used. These are 25%, 50% and 75%. Figure 5.2 shows interface friction angle for different material at 75% water content.

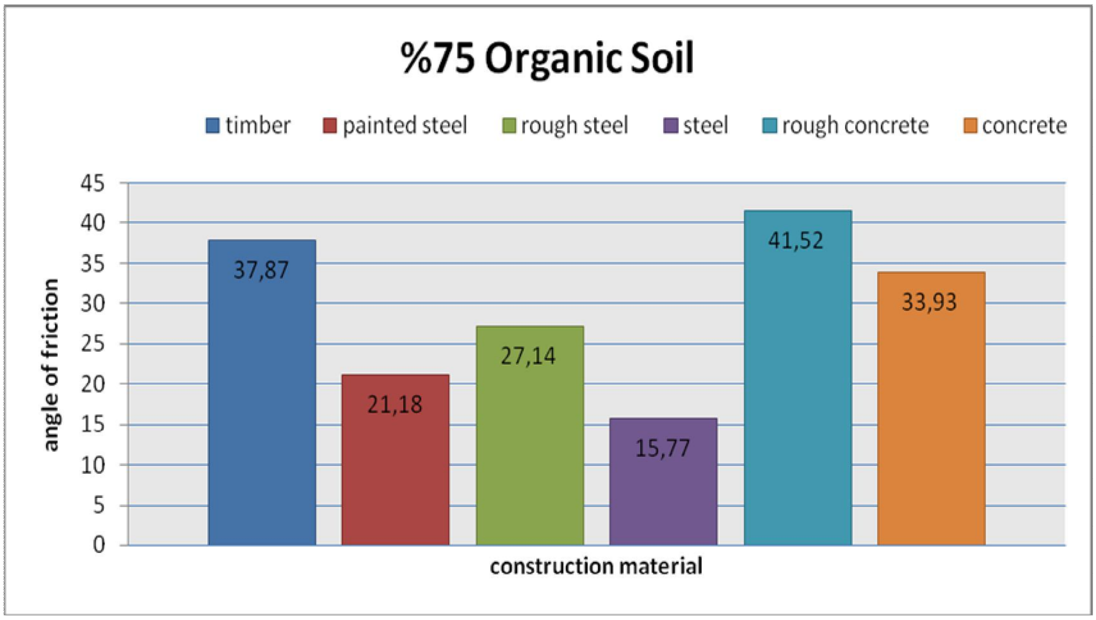

Figure 5.2 Angle of friction of construction materials for % 75 organic soil

As can be seen in figure, highest friction angles was obtained in rough concrete which is 41.52 and lowest interface friction angle was obtained on smooth steel which is 15,77. Interface frition angle for painted steel, rough steel, smooth concrete and timber were 21.18, 27.14, 33.93 and 37.87 respectiely.

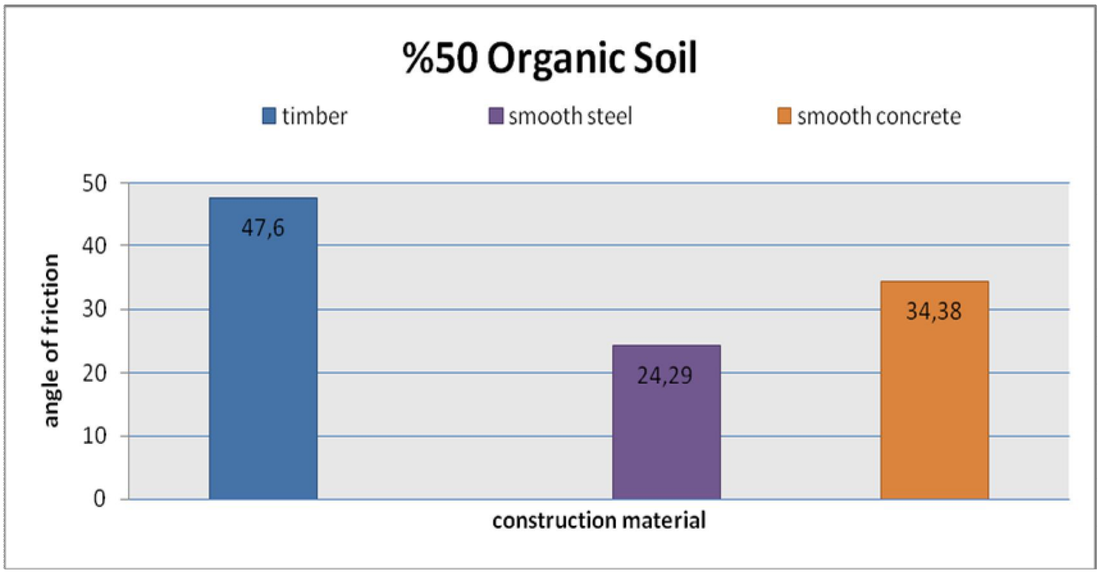

Figure 5.3 Angle of friction of construction materials for % 50 organic soil

As can be seen in figure highest friction angle was obtained in timber which is 47.6 and lowest interface fiction angle was obtained on smooth steel which is 24.29. Interface friction angle for smooth concrete was 34.38 respectively.

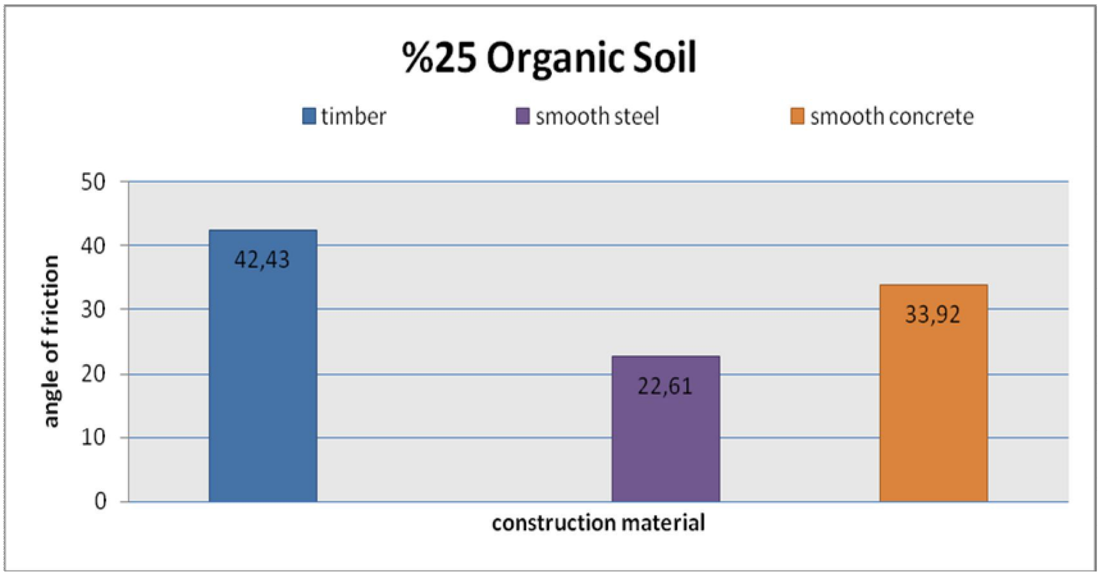

Figure 5.4 Angle of friction of construction materials for % 25 organic soil

As can be seen in figure highest friction angle was obtained in timber which is 42,43 and lowest interface fiction angle was obtained on smooth steel which is 22,61. Interface friction angle for smooth concrete was 33,92 respectively.

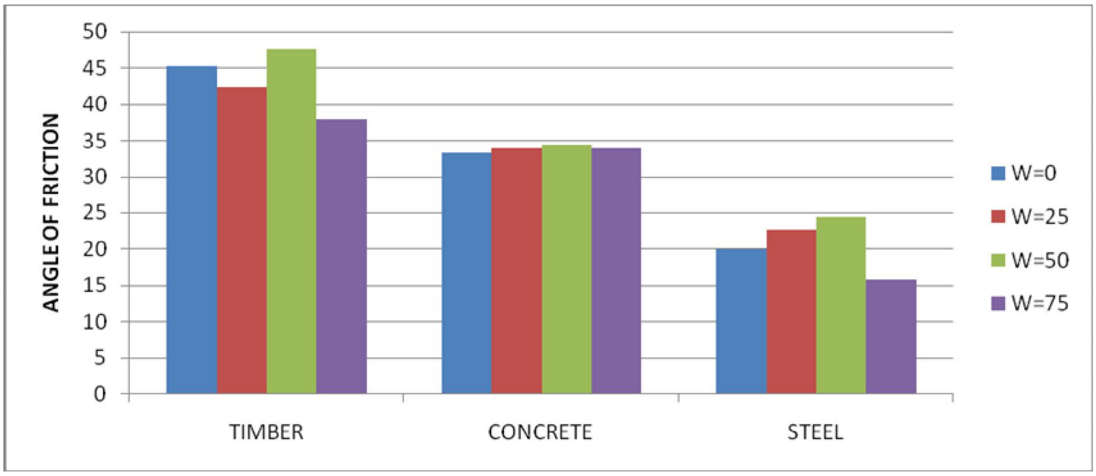

Figure 5.5 Angle of friction of construction materials for different water content organic soil

Figure 5.5 shows change in interface friction angle for different water for same material. As can be seen in figure water content has very small effect on interface friction angle between concrete and organic soil. Friction angle reduces with reducing water content for timber except for 50% water content. Steel shows different behavior then other materials and friction angle increases with increasing water content up to 50% then reduces.

5.4 The relationship between the horizantal deformation of construction materials

Figure 5.9 shows change in horizantal deformation for different load for timber. As can be seen in figure horizantal deformation increases with increasing loads. The response of construction materials interfacing with organic soil at 30 kpa, 60 kpa and 120 kPa normal stresses shows the same characteristic behavior. Horizantal displacement increases with increasing load for construction materials for 75% water content. The frictional response at very large displacements between the organic soil-rough concrete interface was shown. From this figure it can be seen that at large displacements, in the second roughness of the timber affect.

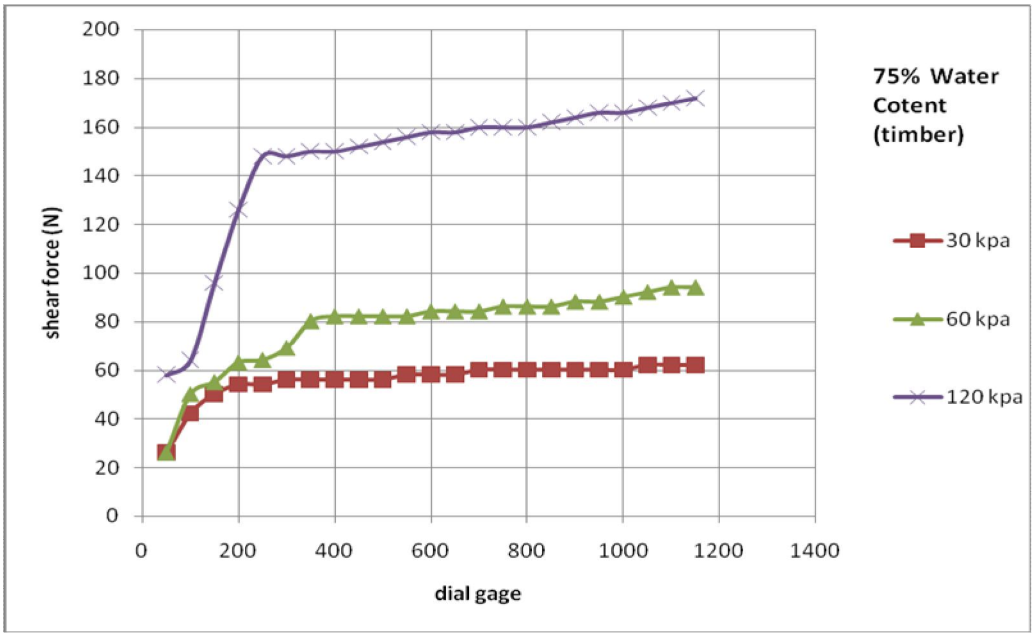

Figure 5.6 Change in displacement under different loads for timber

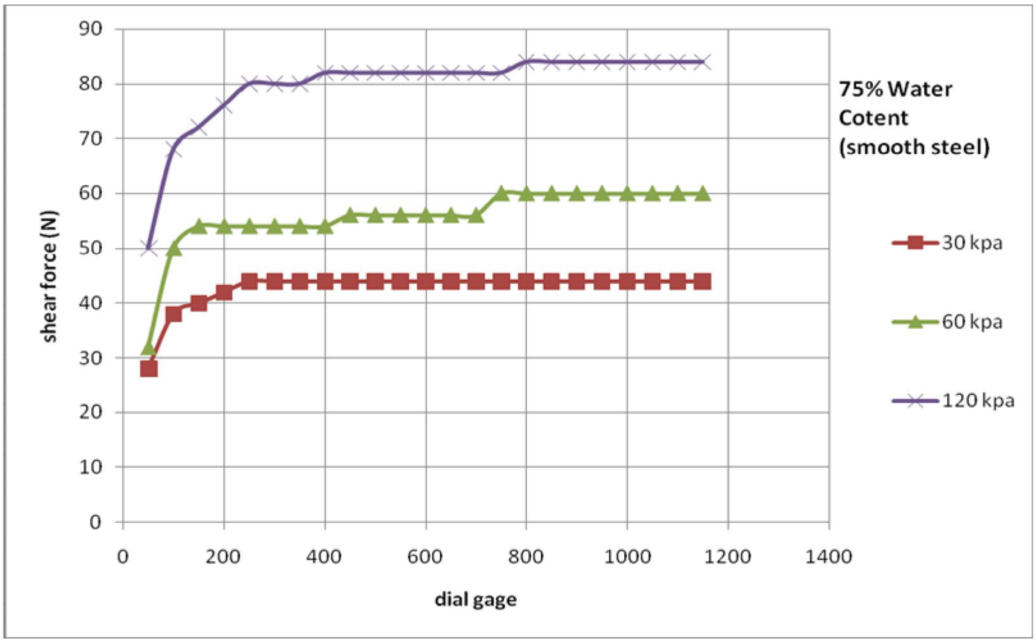

Figure 5.7 Change in displacement under different loads for smooth steel

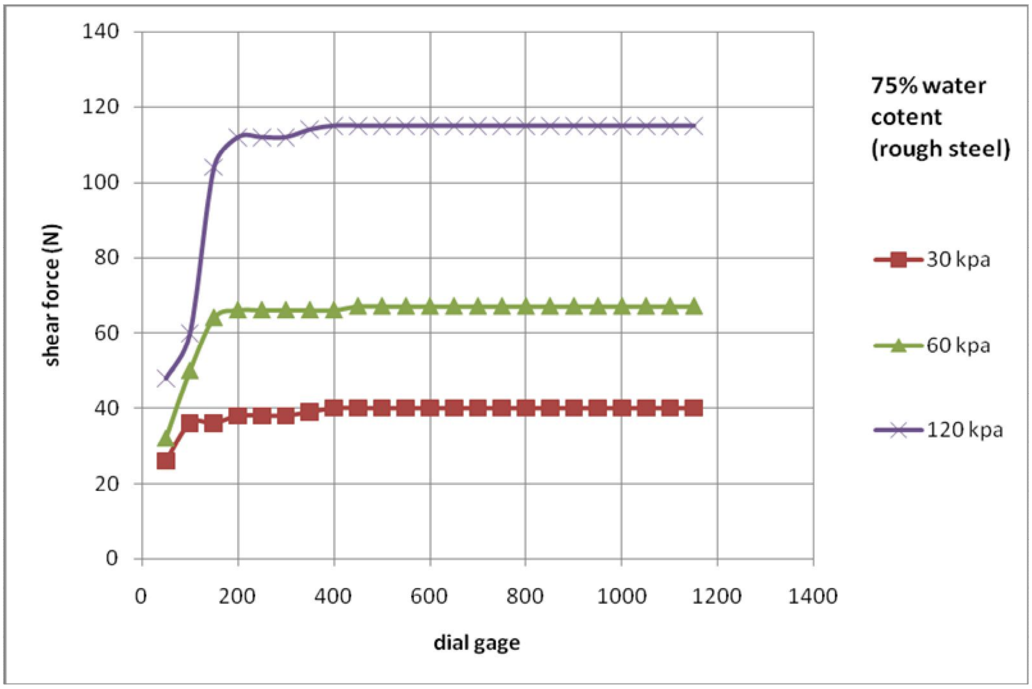

Figure 5.8 Change in displacement under different loads for rough steel

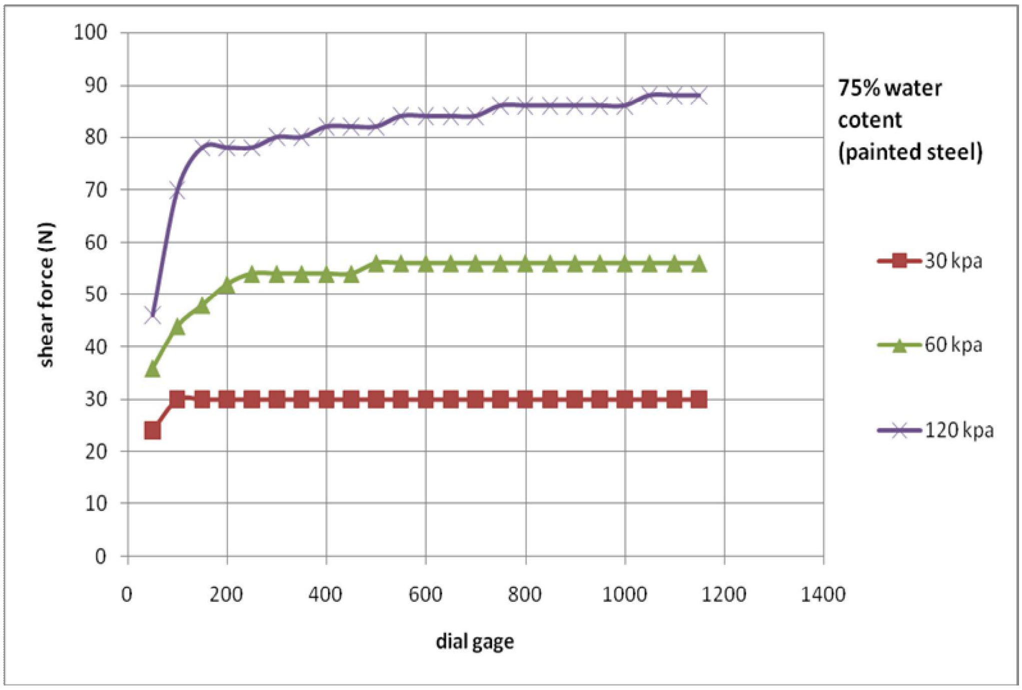

Figure 5.9 Change in displacement under different loads for painted steel

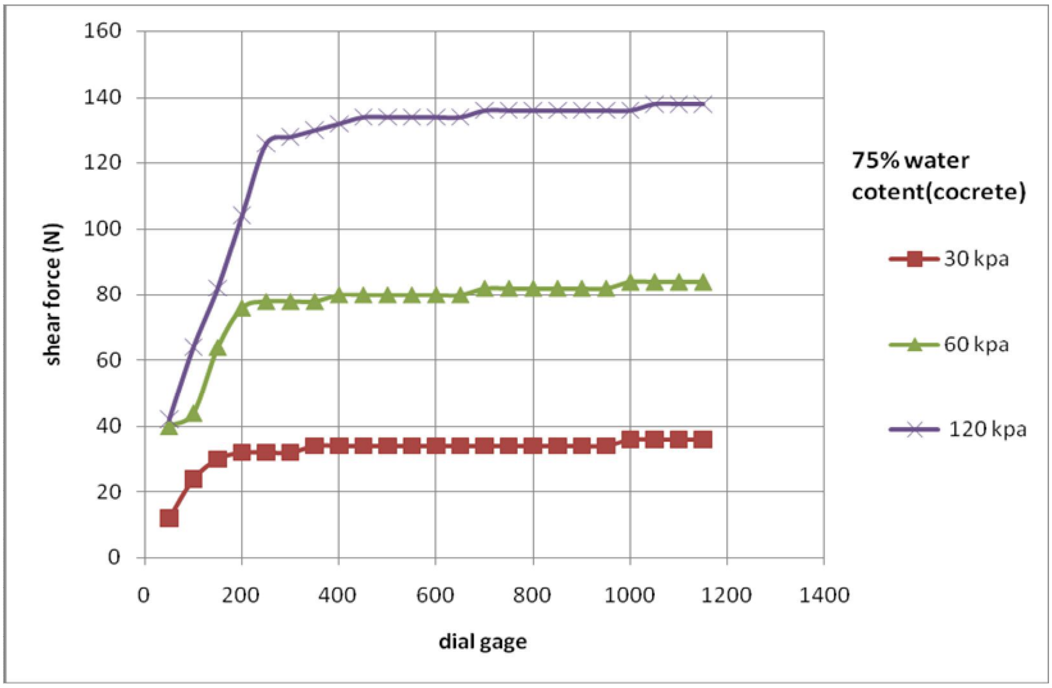

Figure 5.10 Change in displacement under different loads for smooth concrete

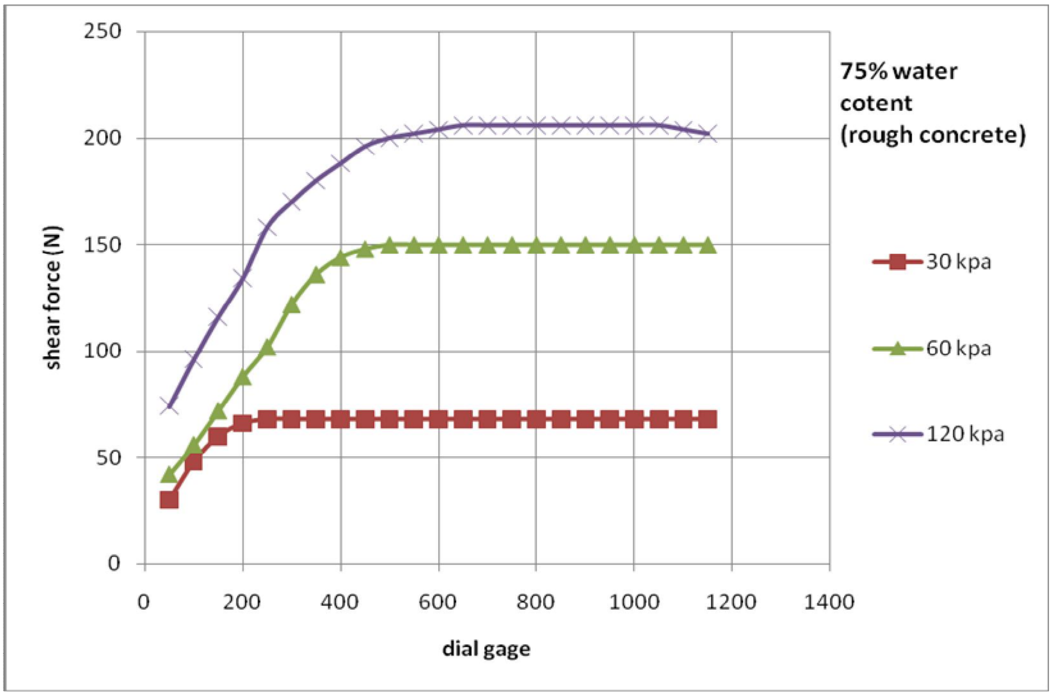

Figure 5.11 Change in displacement under different loads for rough concrete

CHAPTER 6

CONCLUSION

The object these study were to investigate interface friction angle between organic soil and some of construction material such as timber, steel and concrete. Also, effect of water content on interface friction angle fort he some materials were investigated. From the experimante studies, the following general conclusions are drawn.

1. The direct shear apparatus is a useful tool for assessing the friction mobilized at the interface between organic soil and a variety of construction materials.

2. The maximum shear stress increases as the shearing rate increases for all construction materials and for rough and smooth surfaces. Shear stress versus shear displacement curves have no peak values.

3. Test result show that roughness of the construction materials surfaces has important influences on interface friction angle. Rough concrete interface friction angle approximantly 26% higher than smooth concrete.The highest interface friction angle for the steel was obtained from rough steel. Painted steel gives higher friction angle than ordinary steel.

4. Test result on effect of organic soil water content show that it has different effect on different construction material.

5. It was found that water content of the organic soil has no effect on interface friction angle between organic soil and timber.

6. Interface friction angle between steel and organic soil increases with increasing water content upto 50% than decreases.

7. Test result show that interface friction angle between timber and organic soil decreases with increasing water content of organic soil.

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APPENDIX A

APPENDIX A

Horizantal Defermation Shear Stress Graphs

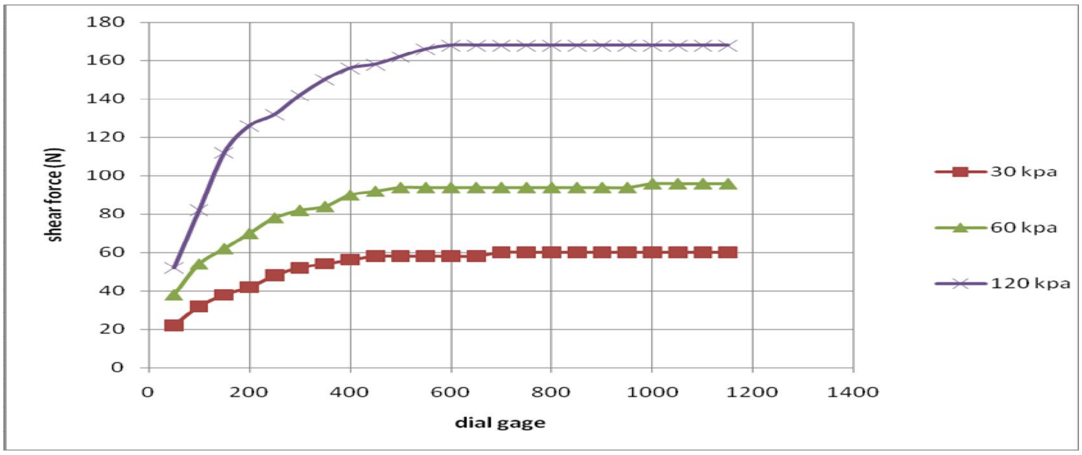

Figure A-1 Timber 0% Water Content

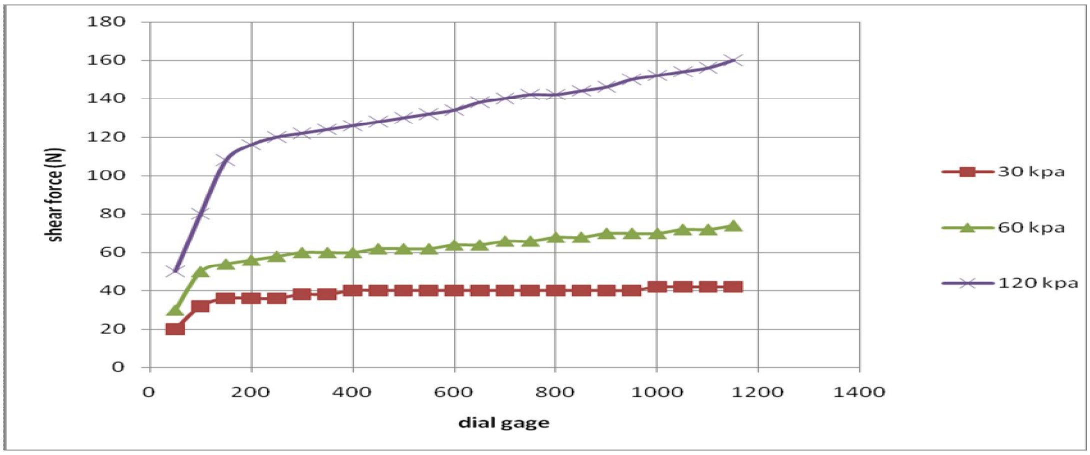

Figure A-2 Timber 25% Water Content

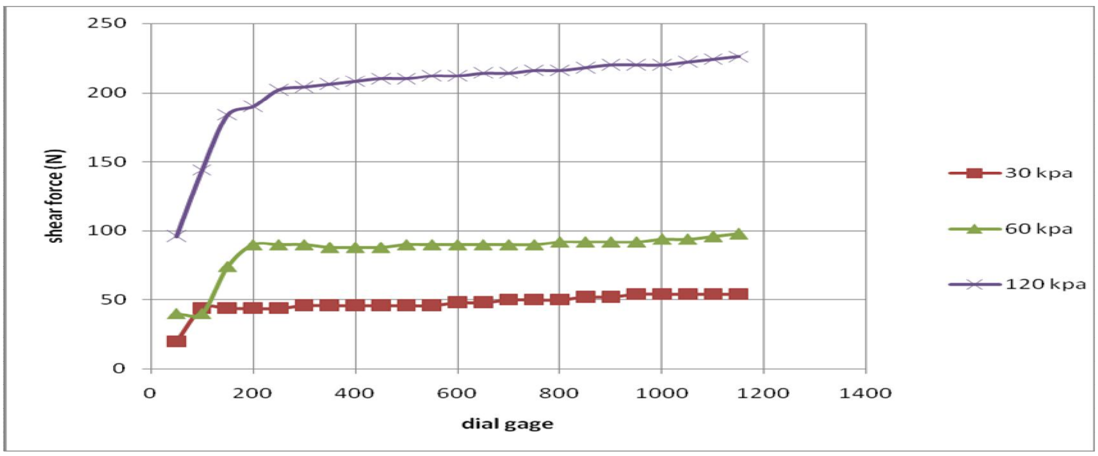

Figure A-3 Timber 50% Water Content

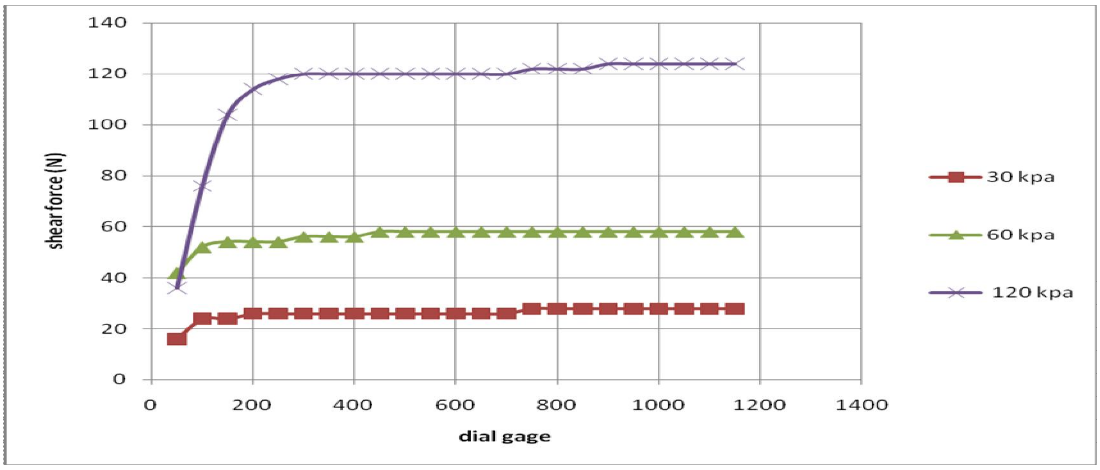

Figure A-4 Smooth Concrete 0% Water Content

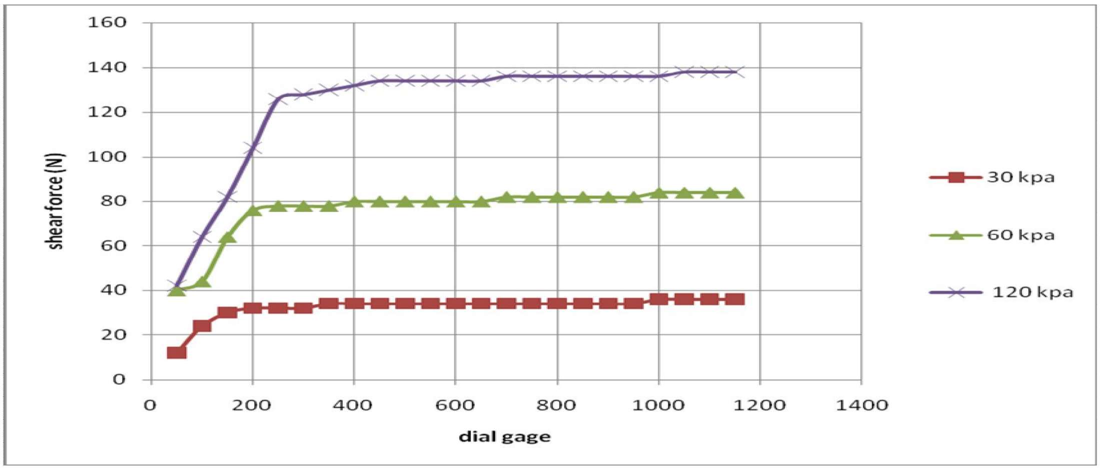

Figure A-5 Smooth Concrete 25% Water Content

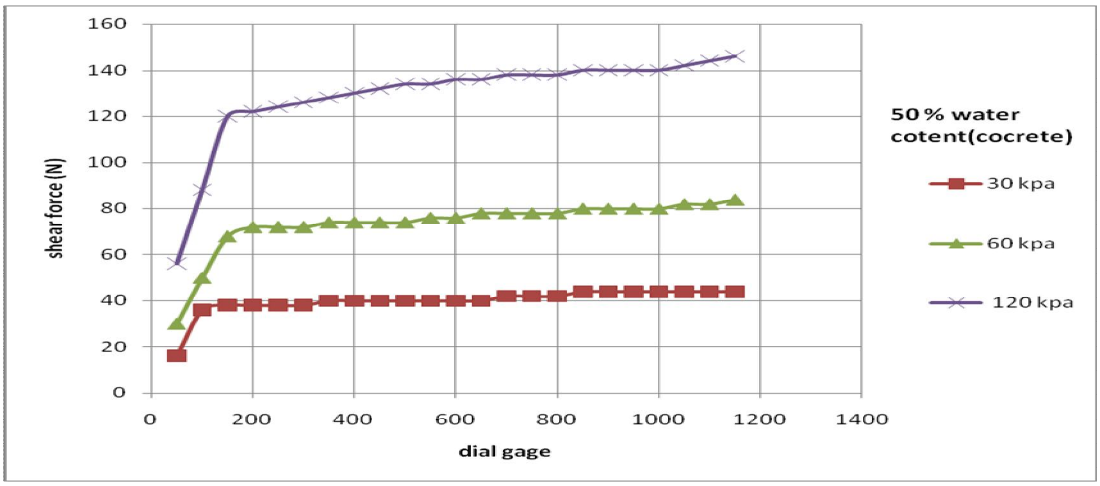

Figure A-6 Smooth Concrete 50% Water Content

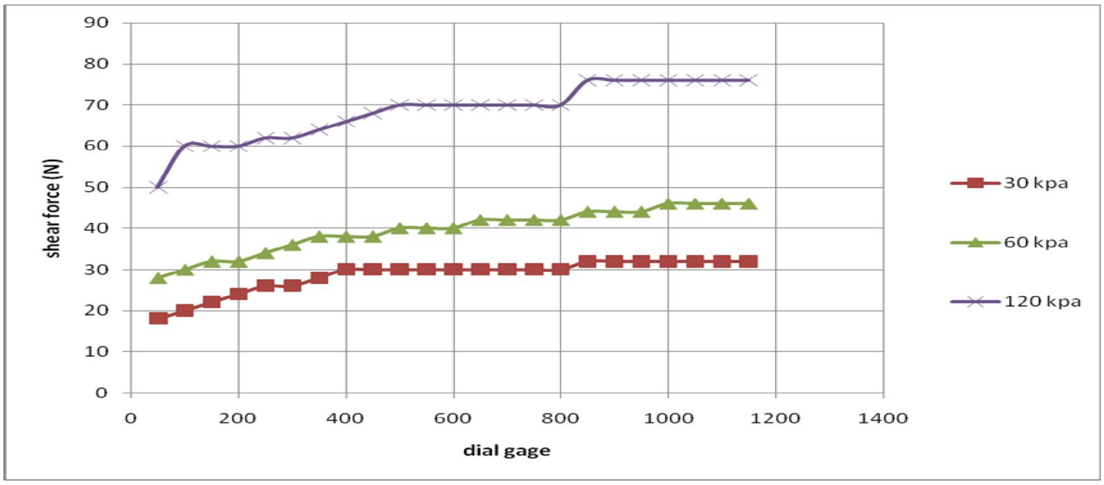

Figure A-7 Smooth Steel 0% Water Content

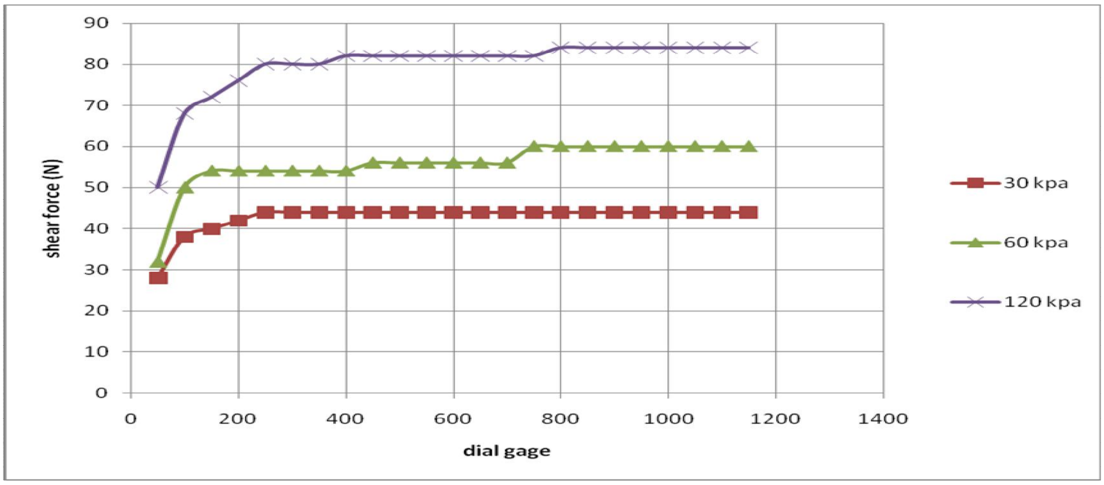

Figure A-8 Smooth Steel 25% Water Content

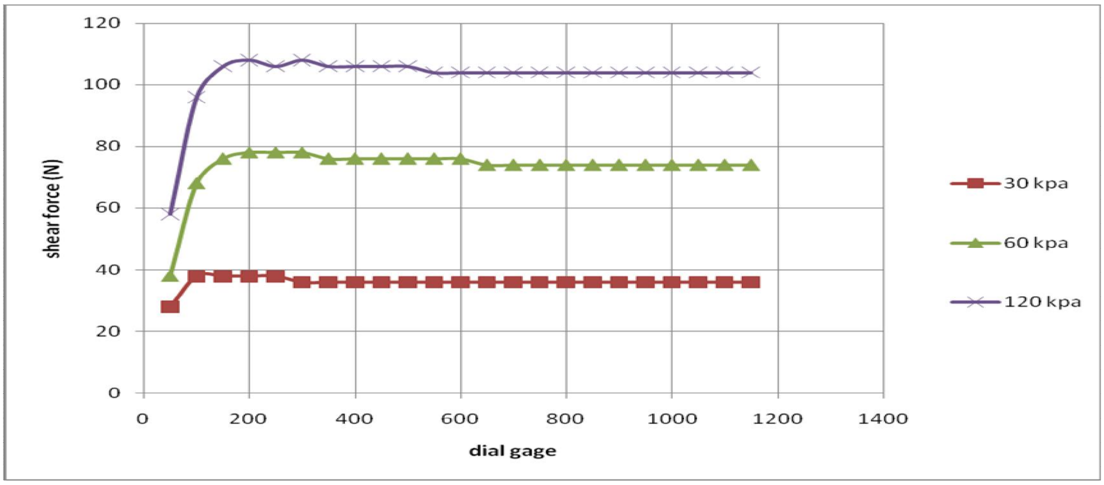

Figure A-9 Smooth Steel 50% Water Content

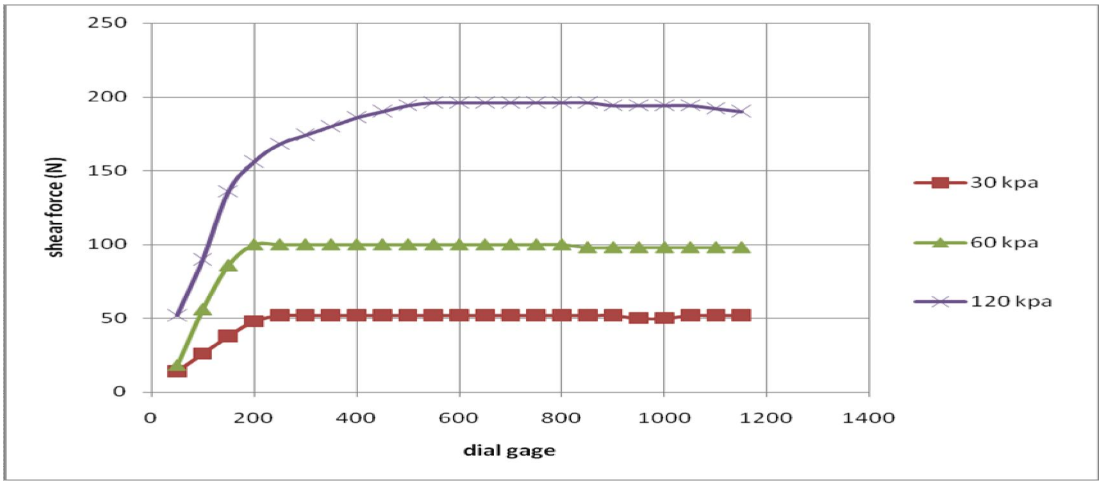

Figure A-10 Rough Concrete 0% Water Content

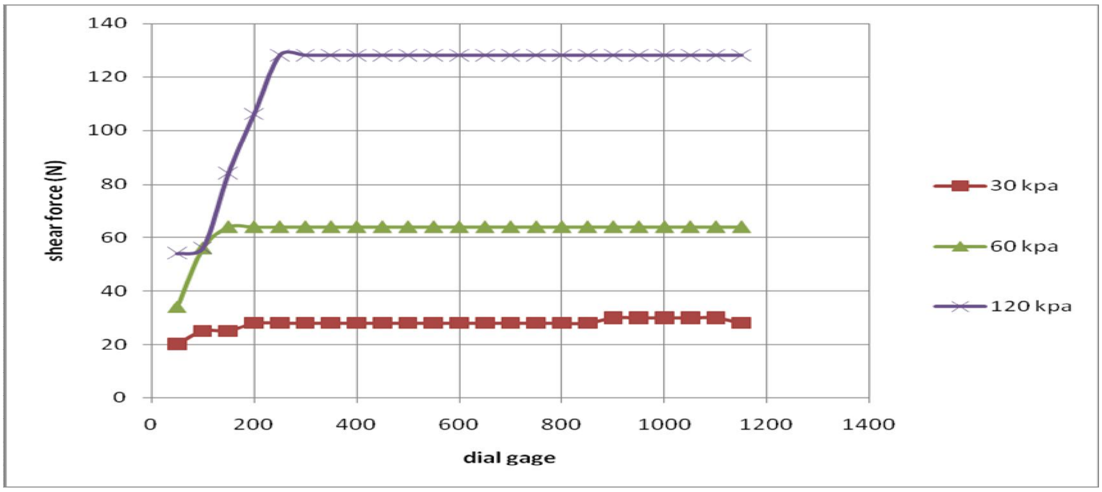

Figure A-11 Rough Concrete 75% Water Content

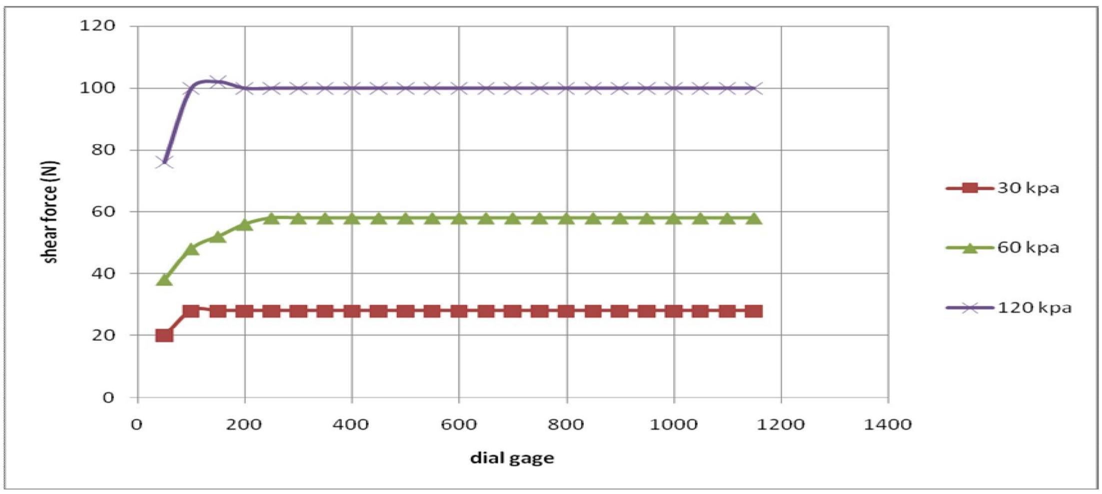

Figure A-12 Painted Steel 0% Water Content

APPENDIX B

APPENDIX B

Inreface Friction Angle

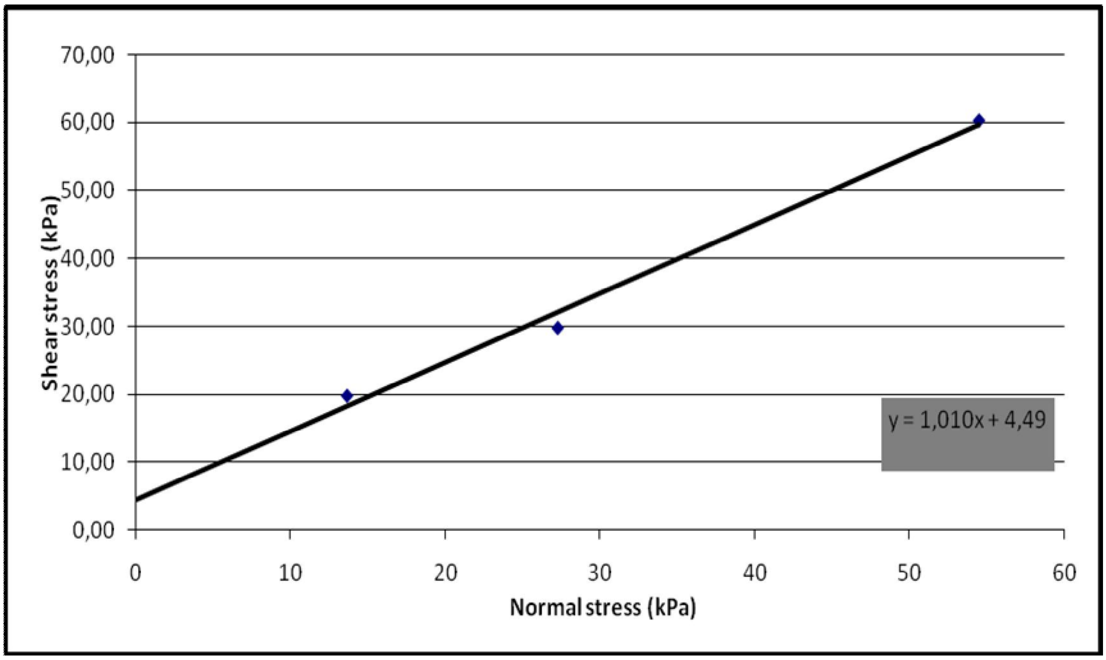

Figure B-1 Timber 0% Water Content(δ = 45.3°)

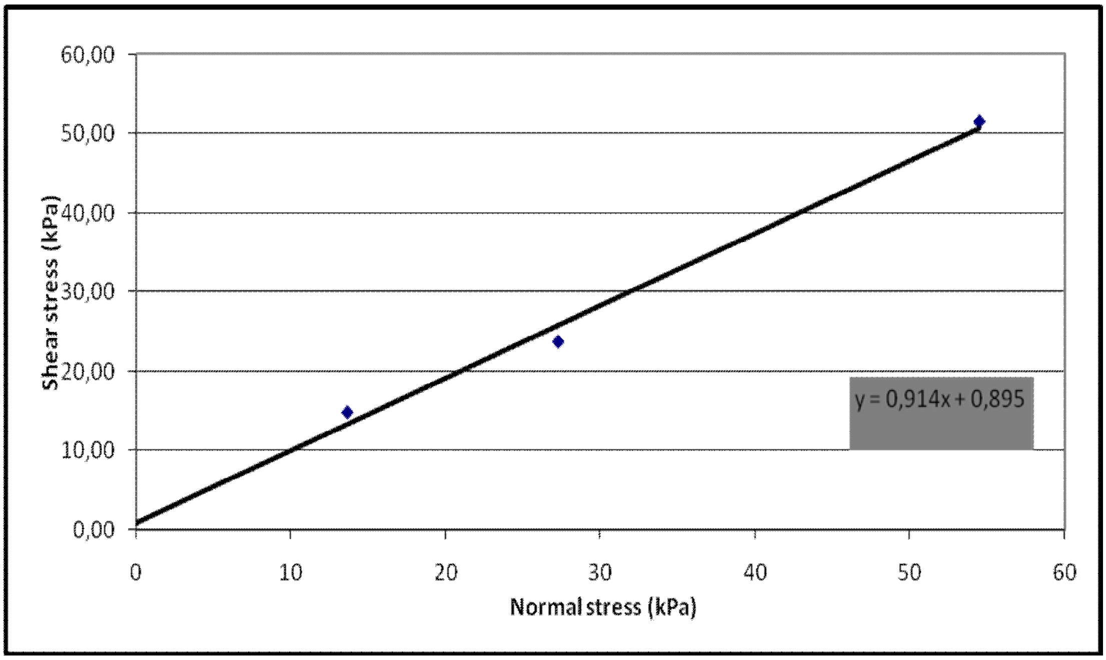

Figure B-2 Timber 25% Water Content (δ =42.43º)

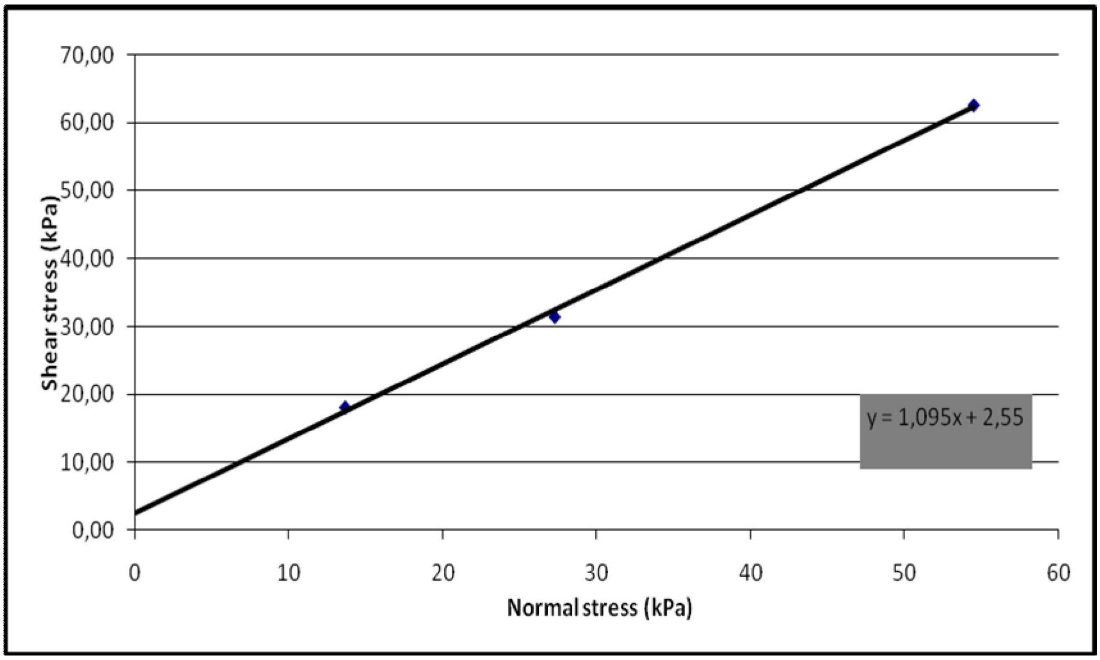

Figure B-3 Timber 50% Water Content (δ=47,60º)

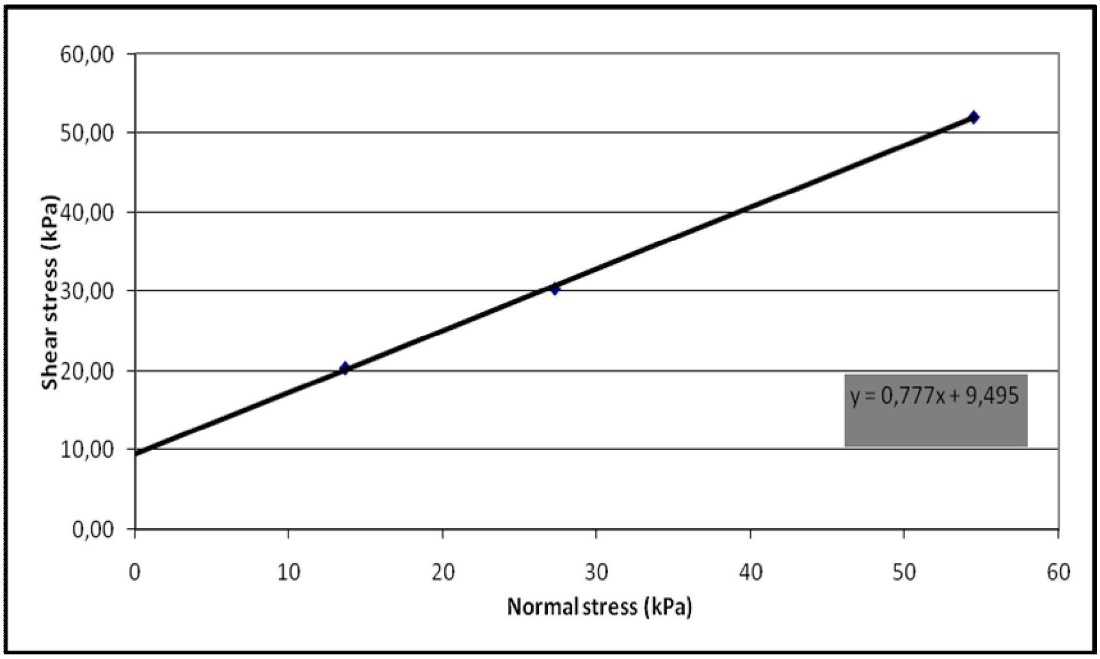

Figure B-4 Timber 75% Water Content (δ= 37,87º)

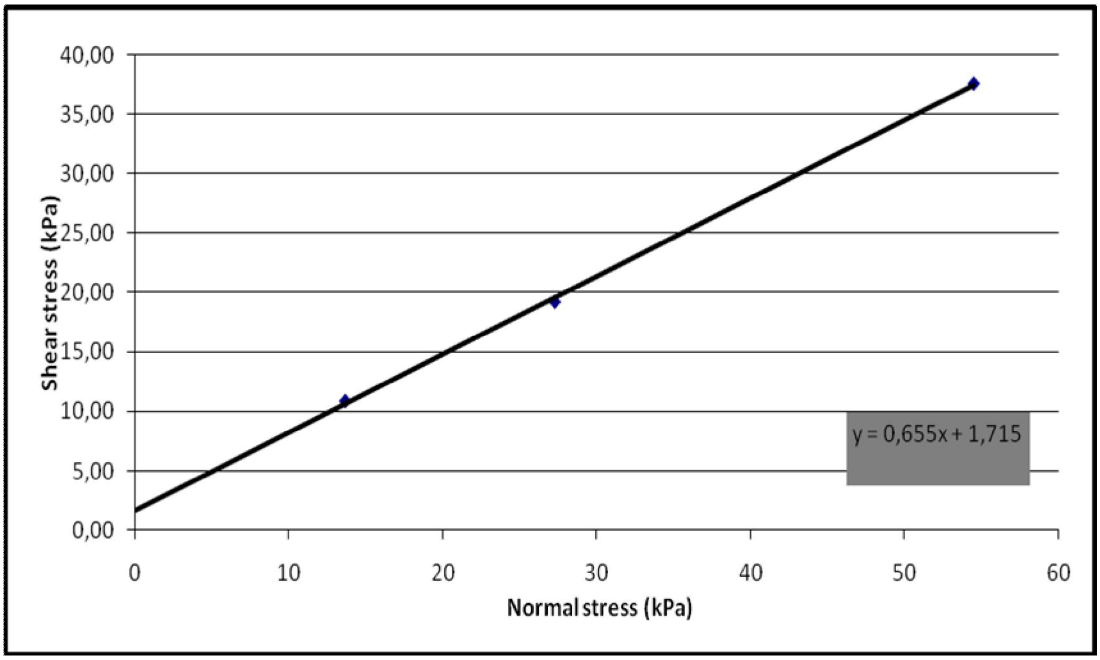

Figure B-5 Smooth Concrete 0% Water Content (δ= 33,24º)

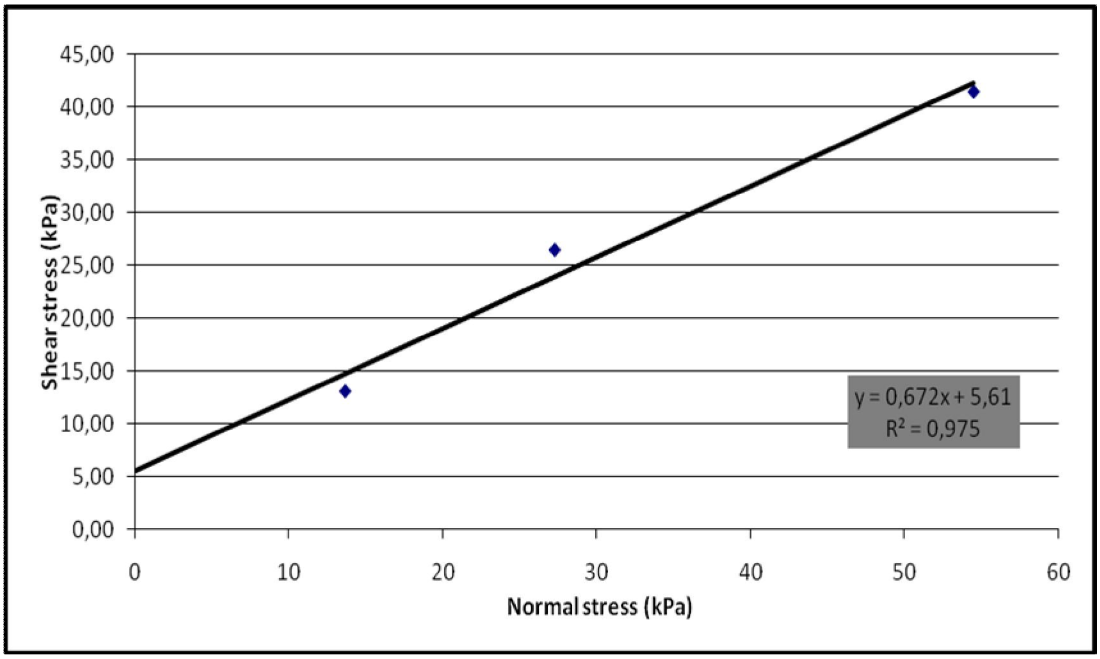

Figure B-6 Smooth Concrete 25% Water Content (δ=33,92º)

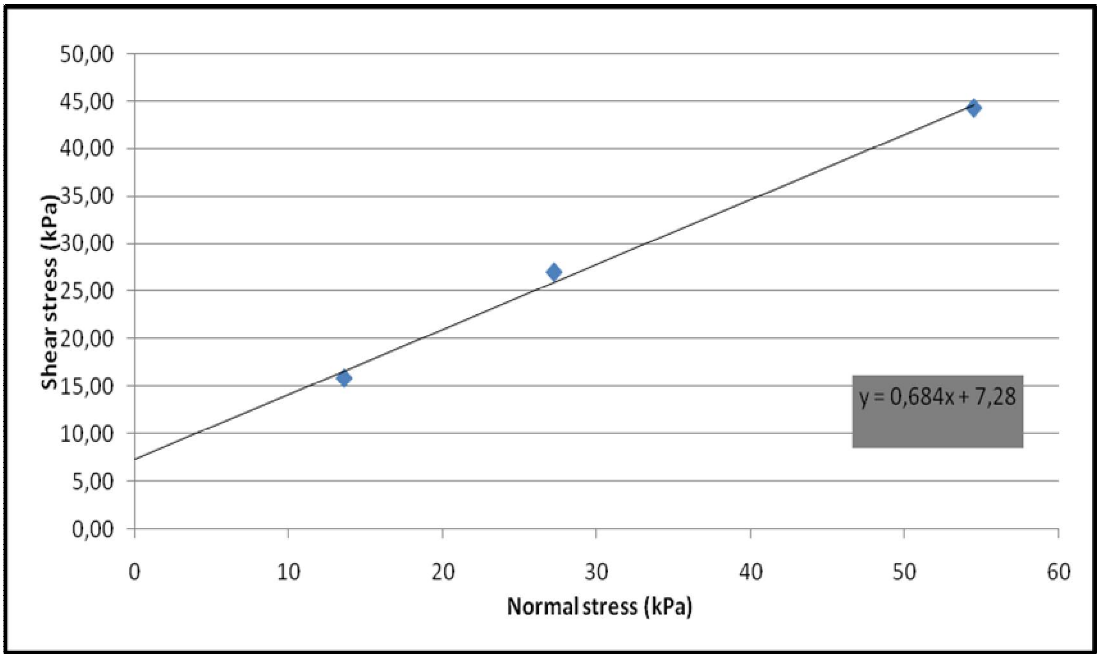

Figure B-7 Smooth Concrete 50% Water Content (δ=34,38º)

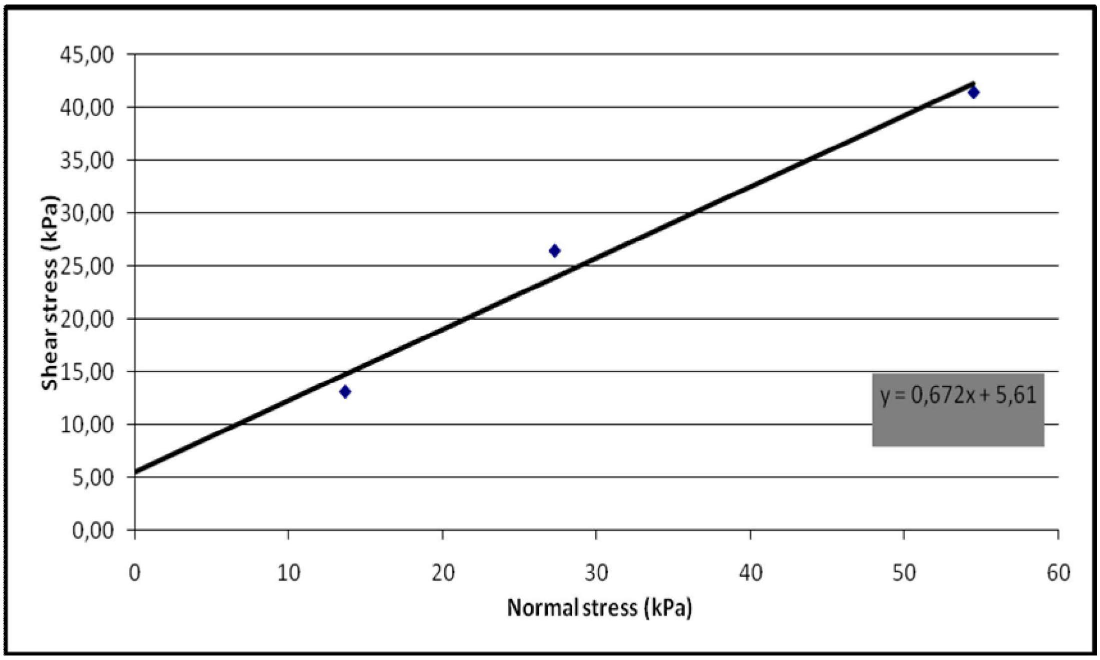

Figure B-8 Smooth Concrete 75% Water Content (δ=33,93º)

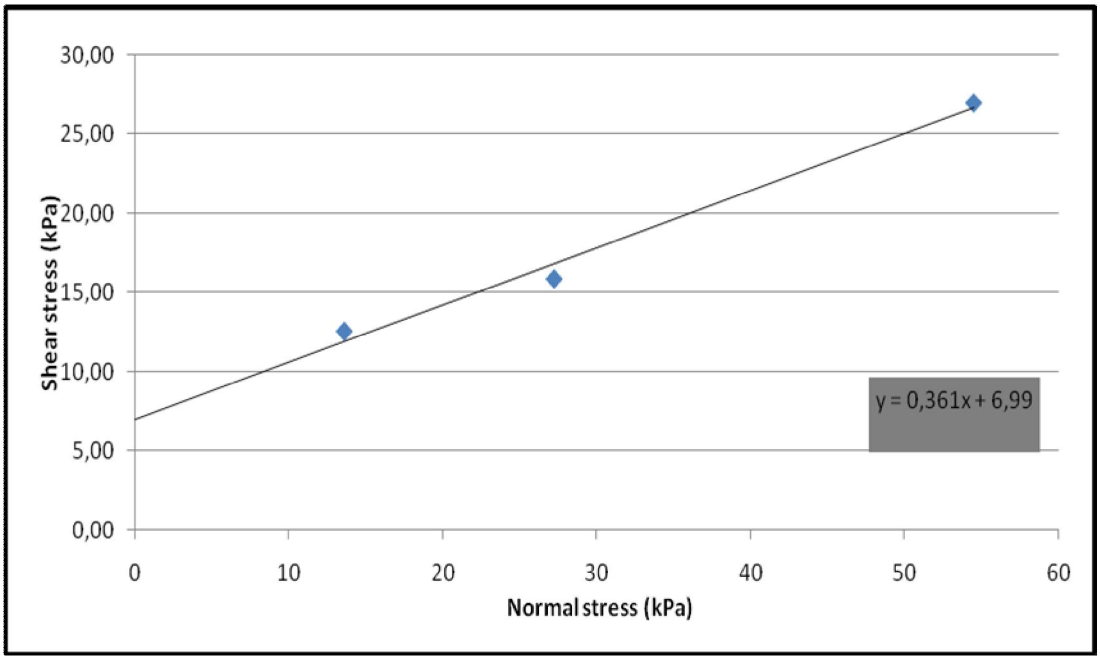

Figure B-9 Smooth Steel 0% Water Content (δ=19,86º)

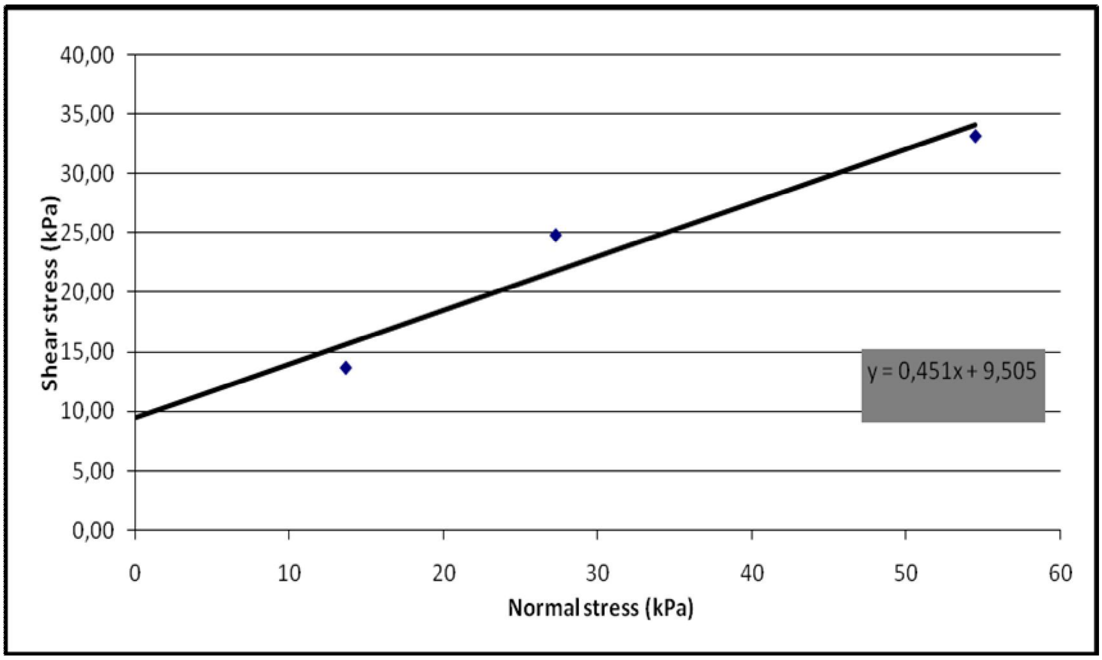

Figure B-10 Smooth Steel 25% Water Content (δ=22,61º)

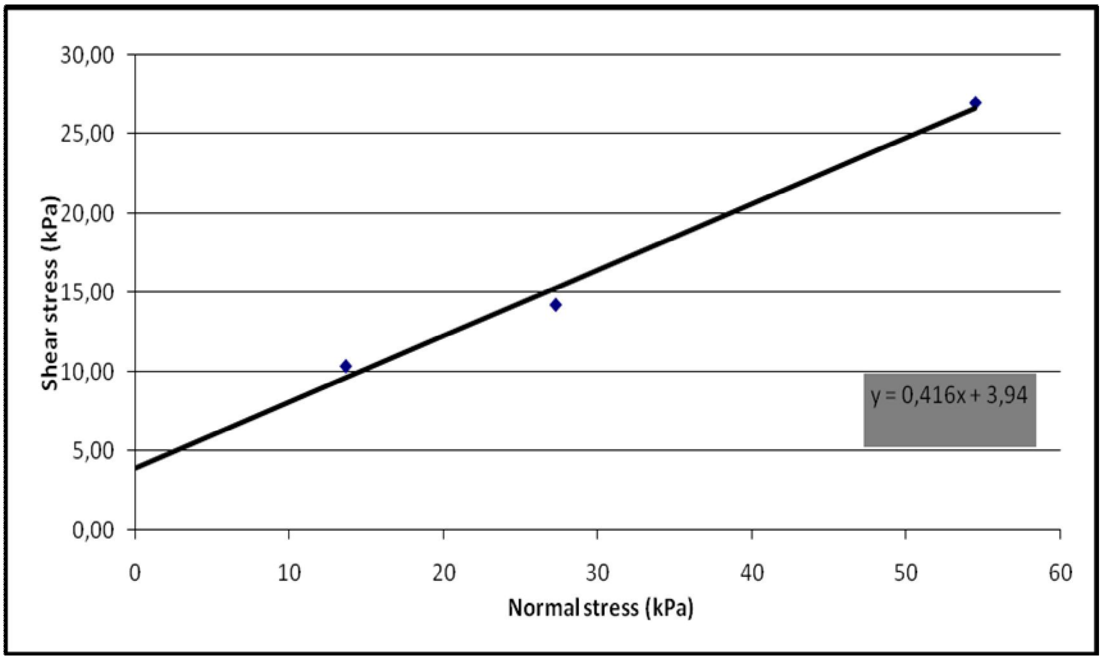

Figure B-11 Smooth Steel 50% Water Content (δ=24,29º)

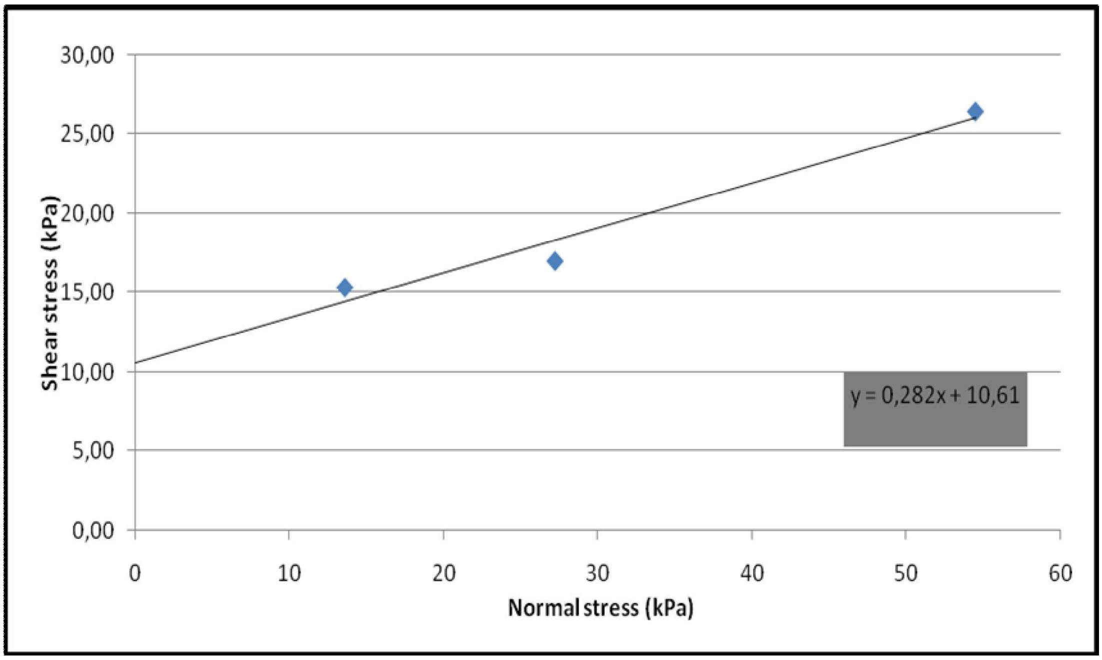

Figure B-12 Smooth Steel 75% Water Content (δ=15,77º)

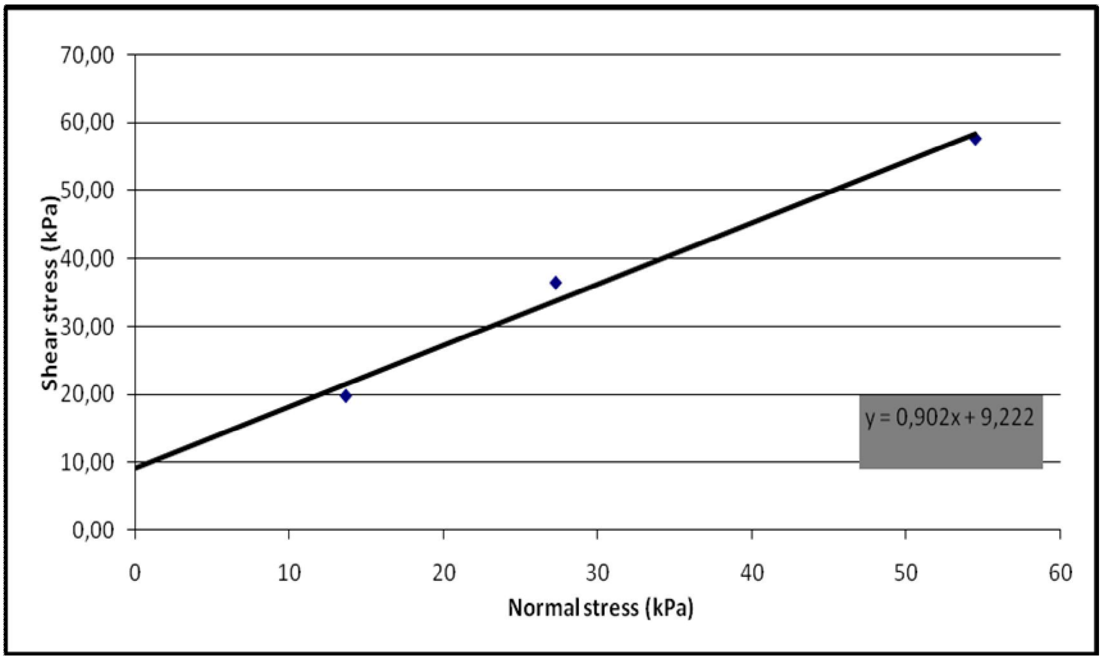

Figure B-13 Rough Concrete 0% Water Content (δ=42,08º)

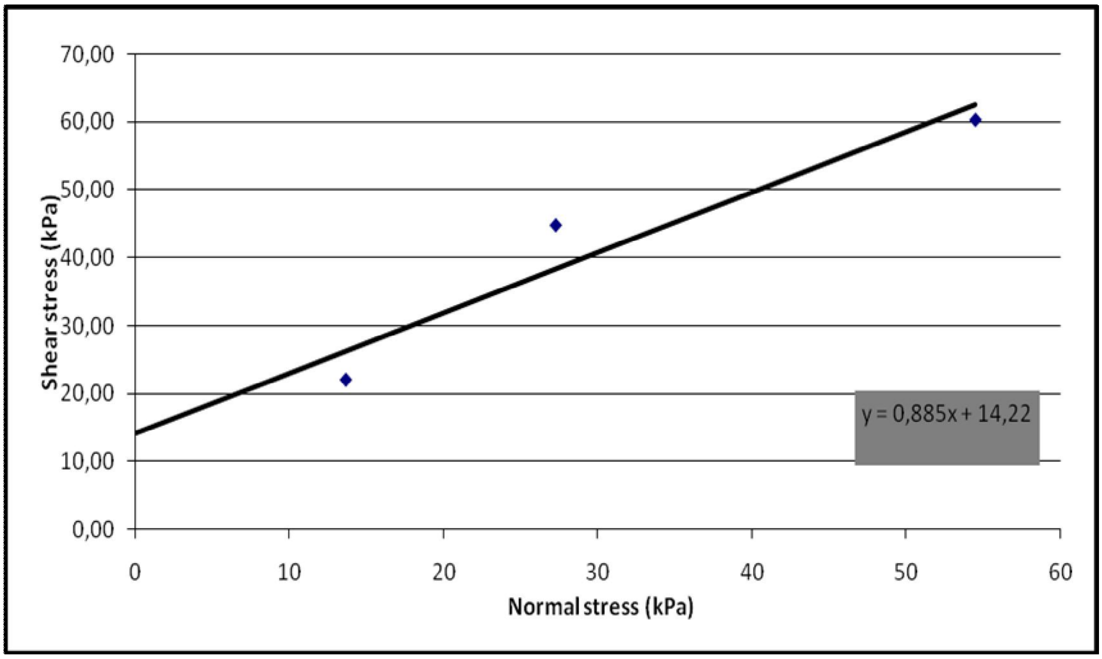

Figure B-14 Rough Concrete 75% Water Content (δ=41,52º)

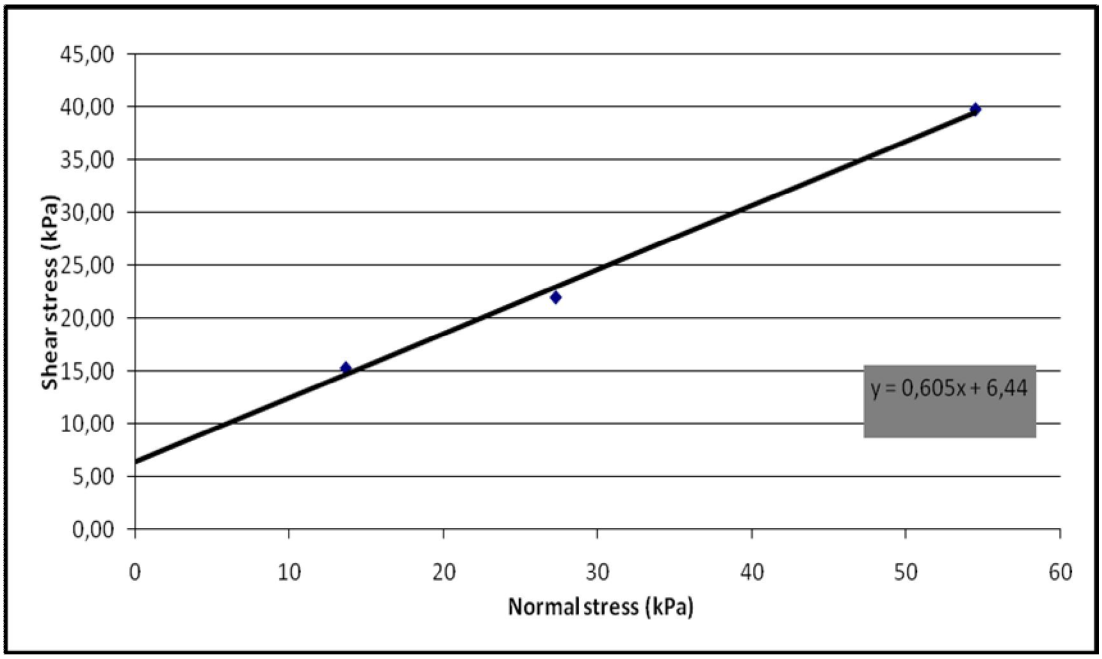

Figure B-15 Rough Steel 0% Water Content (δ=31,21º)

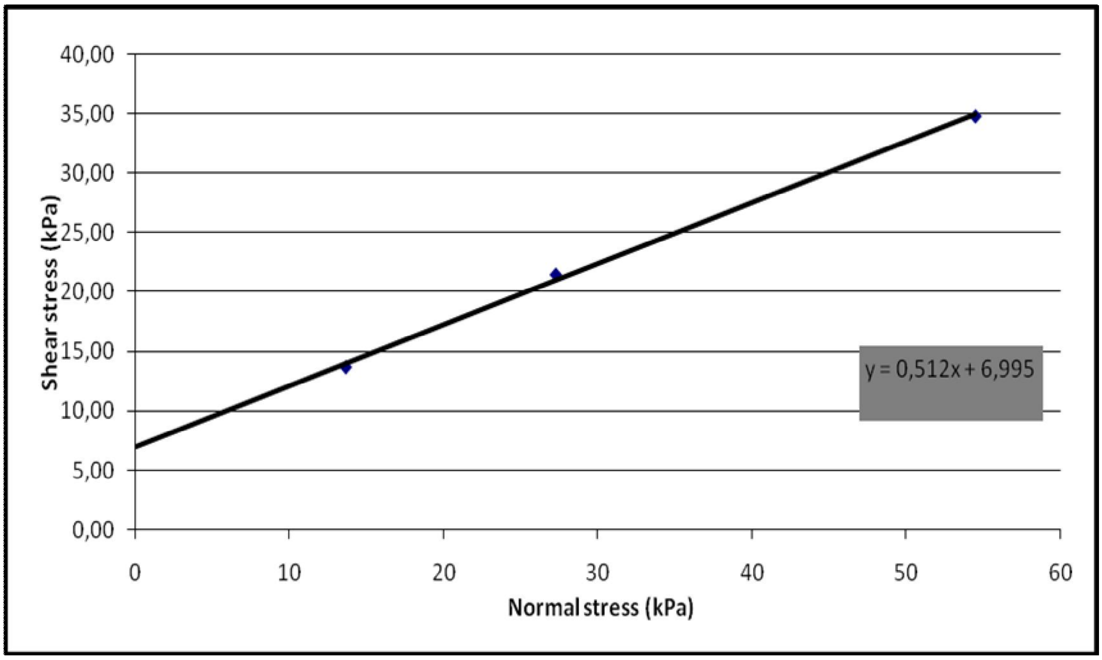

Figure B-16 Rough Steel 75% Water Content (δ=27,14º)