Minor Project Completion Report

on

A Study on Reduction of Building Plinth Wall Thickness by Application of Coir/Jute as Geotextile and Waste Material as Anchor Bar

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ABSTRACT

Building plinth walls are most commonly constructed with full brick thickness. Reducing the thickness of brick masonry plinth walls of Assam type buildings from 1 Brick thick to ½ brick thick will, in addition to reduction in cost of construction, result in lesser consumption of burnt clay bricks and thus contribute positively to environment. This study explores the possibility of improving stability of the plinth fill soil by premixing it with coir fibers. Laboratory tests are performed adding different % of coir with the plinth fill soil. The results show improvement of the soil behaviour up to an optimum fiber content thereby reducing the lateral pressure exerted by the soil on the plinth wall. The study also explores whether the concept of Earth Retained walls using anchor rods made of waste material can be economically applied for additional stability of plinth walls. Ropes cut out of used tyres are tested in the laboratory to study its potential to be used as anchor rods in plinth wall construction. Encouraging results regarding tensile strength and bond strength of the rope with soil has been observed in the test results. Details of these results are reported in this work.

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CHAPTER 1

INTRODUCTION

Economic use of materials is one of the major considerations in building construction. With the depleting natural resources to supply the raw materials required for the construction industry alternative / modification of construction methods is continuously explored with a view to reduce the quantity of raw materials used and improving the properties of materials used. Increasing the strength of soil is an important aspect that can explored and various methods regarding improving its strength can be investigated.

Building plinth walls are most commonly constructed with full brick thickness. Reducing the thickness of brick masonry plinth walls of Assam type buildings from 1 Brick thick to ½ brick thick will, in addition to reduction in cost of construction, result in lesser consumption of burnt clay bricks and thus contribute positively to environment. An attempt to reduce the thickness of plinth wall requires,

a) Enhancement of the material quality and strength of the wall and

b) Increasing the stability of the plinth fill soil so the net lateral load of this infill soil on the wall is reduced.

This study plans explores the possibility of improving stability of the plinth fill soil by premixing it with admixtures. Since the buildings under study are mostly used by lower or lower-middle income group of population the admixture needs to be effective, economical and environment friendly. Coir is one of the most abundantly available natural raw materials in NE India. Coir has been effectively used as geotextile material in road construction. In this study it is planned to explore the possibility of improving the stability of the infill soil by mixing it with commercially available coir rope.

It is also planned to explorewhether the concept of Earth Retained walls using anchor rods made of waste material can be economically applied for additional stability of plinth walls. It is seen that used waste tyres are manually cut into rope shape and used for various purposes like drawing water from open wells etc. These ropeshave not found their use in construction industry and it is observed that these ropes have immense potential to be used as anchor rods in earth retaining structures. This work will study the possibility of using ropes made out of waste tyres as anchor ropes. This will not only increase the stability of the plinth wall but also help keeping the environment green by disposing off waste tyres without burning.

CHAPTER 2

REVIEW OF AVAILABLE LITERATURE

The present scenario in the construction industry demands more economic housing. In India, there is a growing need for the use of advanced technology in reducing the cost of construction. Many researchers are continuously working on this idea to develop an economic as well as environment friendly solution to the ever increasing prices of construction of homes, which is a basic necessity of life.

Anggrain et al. (2015) investigated the tensile and compression strengths of natural and treated soft soil. The tensile strengths and compression strengths of compacted specimens of natural soil, lime and coir fiber treated soil were obtained using the indirect tensile test and unconfined compressive test. The results revealed that both tensile and compressive strengths increased with the addition of lime, coir fiber and the increasing of the curing time. From the test results, the relationship of the unconfined compressive strength of the soft soil was predicted by the correlation agreed with the indirect tensile strength. It was indicated that lime and fiber reinforced soils took on the strain-hardening ductile failure characteristic. The load causing this failure was the highest obtained during the test, and the outer fractures occurred subsequent to the central fracture.

Satyanarayana et al. (1981) reviewed the early research on the structure and properties of coir fibres. Gaps in the scientific information on the structure and properties of coir fibre have been identified. Attempts made to fill some of these gaps include the evaluation of mechanical properties (as functions of the retting process, fibre diameter and gauge lengths of fibre, as well as of the strain rates) and fracture mechanisms using optical and scanning electron microscopy. The deformation mechanism of coir fibre resulting in certain observed properties has been discussed with the existing knowledge of the structure of plant fibres as a basis. It is concluded that more refined models need to be developed for explaining the observed mechanical properties of coir fibres. Some of the suggestions for further work include relating properties of fibres to factors like the chemical composition of the fibre and the size and number of cells, size of lumen, variation in micro-fibril angle within each cell and between different cells of the same fibre, and understanding the deformation of the whole fibre in terms of deformation of individual micro-components. Further work is required on the effects of mechanical, thermal and thermomechanical, chemical treatments to modify the structure and mechanical properties of these fibres in such a way as to make them more suitable as reinforcements in polymer, clay and cement matrices.

Abhijith R.P (2015)this paper deals with an experimental study on the utilization of natural coir fibers on unpaved roads. Coir fibres provide a reinforcement action to the subgrade soil. Coir fibre is a natural material obtained from coconut husk which is commonly seen in India. Use of coir fibres improves the subgrade soil strength. Coir fibers of varying length from 0.5 to 3cm and varying percentage from 2 to 8 of total weight of soil were added with the soil and CBR test was conducted. From the test results, it was concluded that the CBR strength using coir fibre was improved and optimum fibre length obtained was 1.5cm and optimum fiber content was 5% of total weight of soil. CCM-400 Coir Geotextile which is a woven type coir mat was placed at ¼ th, ½ th, ¾ th and top positions of soil sample and CBR test were conducted. The results concluded that placing geotextiles at two third depth from bottom position was seems to be more effective.

Ghosh et al. (2014) Analysis and comparison of properties of two different clayey soils is carried out with and without reinforcement in this paper. Jute geo-textile (grade TD-5) was used as reinforcing material to stabilize both peat and black cotton soil. Almost all the standard laboratory tests as well as field tests were conducted. Finally study of the contribution of jute geo-textile on the properties of clayey soils and its feasibility for various civil engineering applications is evaluated. The results show the increment of soil properties like shear strength, dry density and CBR (California Bearing ratio) while permeability and settlement decreased on introduction of jute geo-textile, indicating significant improvement in the engineering behavior.

Bhattacharyya et al. (2010) the objective of this review is to analyse the effects of plot length (*L*) and other possible affecting factors [cover percentage (*C*, %), slope gradient (*S*), rainfall duration (*D*), rainfall intensity (*I*), sand, silt and clay contents, soil organic matter (*SOM*) content and geotextile type (natural or synthetic)] on the effectiveness of geotextiles in reducing soil and water loss, based on reported experimental data. From linear regressions, *C* (%) and soil sand, silt and clay contents are found to be the most important variables in reducing *SLR* (ratio of soil loss in bare plots to that in geotextile treated plots) for splash, *C* (%) for interrill and *D* (min) for rill and interrill erosion processes, respectively. Soil clay and silt contents and *D* are key variables in decreasing *RR* (ratio of runoff from bare plots to that from geotextile treated plots) for interrill, and clay content for rill and interrill erosion processes, respectively. The linear relationship between mean b-value (geotextile effectiveness factor in reducing soil loss) and *L* of all studies was not significant ($P > 0.05$). The same is true for the relationship between *L* and *SLR*, and *L* and *RR*. However, when *L* is added to an equation as an interaction term with *C* (%), geotextile cover is significantly ($P < 0.05$) more effective in reducing *SLR* on shorter plots than longer ones for both interrill and rill and interrill erosion processes. Buffer strip plots (area coverage ~ 10%) with Borassus and Buriti mats have the highest *b*-values.

Mali et al. (2014)studied that soft silty or clayey soils are extensively distributed worldwide and they can be improved with reinforcement in the form of randomly distributed fibers of natural and synthetic types. Among the natural fibers, coir and jute are produced in large quantities in South Asian countries. Polypropylene, polyester, polyethylene and glass fibers are widely available synthetic fibers. It is necessary to determine the optimum fiber content and fiber length for any fiber type in the laboratory prior to field applications. This paper reviews the strength behavior of cohesive soils reinforced with coir fibers, polypropylene fibers and scrap tire rubber fibers as reported from experimental investigation, that includes triaxial, direct shear and unconfined compression tests.

SivakumarBabu and Vasudevan (2008) investigated the strength and stiffness response of coir fiber-reinforced tropical silty soil of intermediate plasticity, and reported the effect of fiber content and fiber length on the strength and stiffness characteristics of the soil. Fig. 1 presents a typical result of the stress versus strain response for various fiber contents. The results show that the deviator stress at failure increases with fiber content and occurs at about 10–18% of strain. The optimum fiber content corresponding to maximum improvement in strength is found to be 2.0-2.5%. Fig.1 shows the effect of length of coir fibers on stress-strain response. Maximum
improvement is obtained with 15 mm long fibers. To avoid the possibility of boundary effects for 30 mm long fibers, length in the range of 15–25 mm (40–65% of least lateral dimension of 38 mm) was considered to be appropriate to obtain improvement.

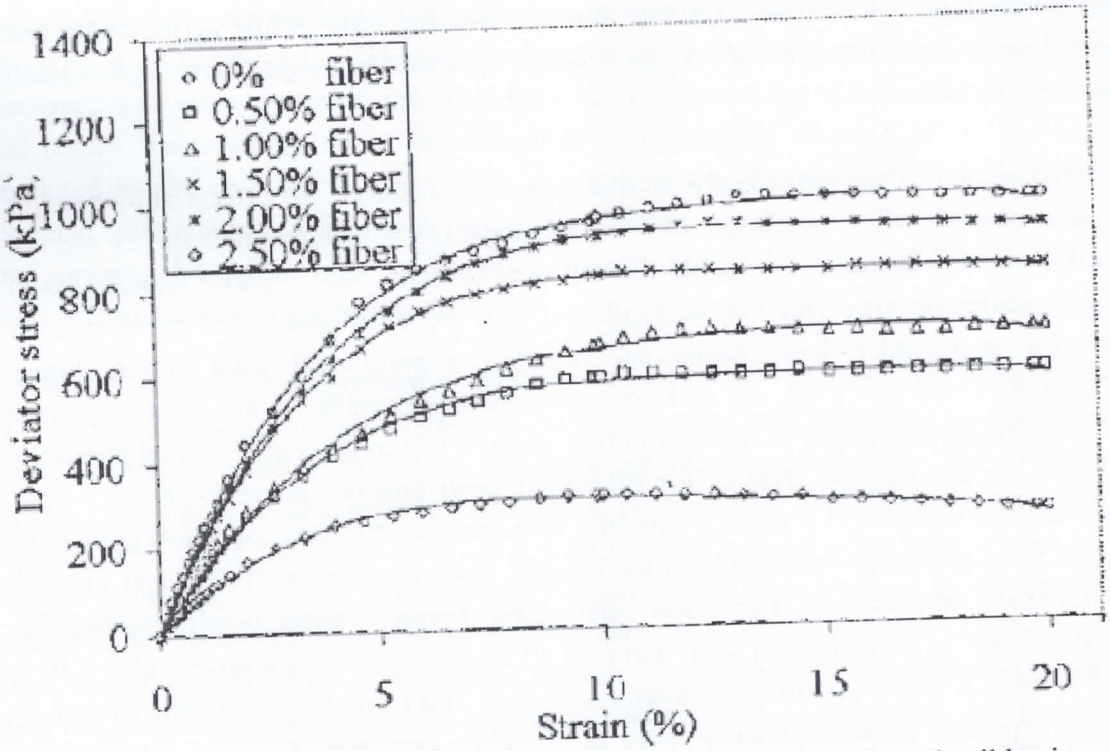


Fig. 1: Stress versus strain curves for coir fiber-reinforced soil having differentfiber contents at 50 kPa confining pressure

Maliakal and Thiyyakkandi (2013) studied the influence of randomly distributedcoirfibers on the shear strength of a silty soil of high plasticity. Fig. 3 shows typical deviator stress-strain plots for unreinforced clay and coir fiber-reinforced clay withdifferentfiber contents. It is evident that inclusion of coir fibers significantly alters thestress-strain characteristics of clay. At higher fiber contents (1 and 2%), no peak is observed until the conventional serviceability failure state of 20% strain, whereasunreinforced clay attains peak deviator stress at an axial strain of about 10–15%. Fig. 4presents the deviator stress-strain plots for coir fiber-reinforced clay with differentaspect ratios at constant fiber content. The trend of the response with varying aspectratio is identical to that with varying fiber content as depicted in Fig. 3.

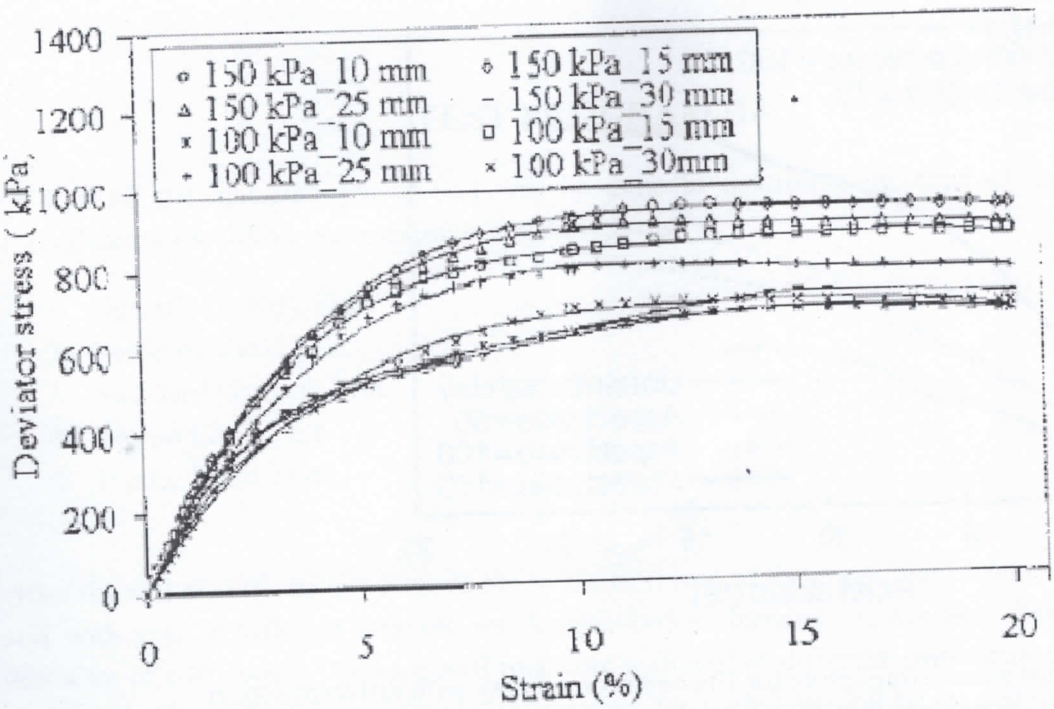


Fig. 2: Stress versus strain curves for coir fiber-reinforced soil having differentfiber lengths at 150 kPa confining pressure

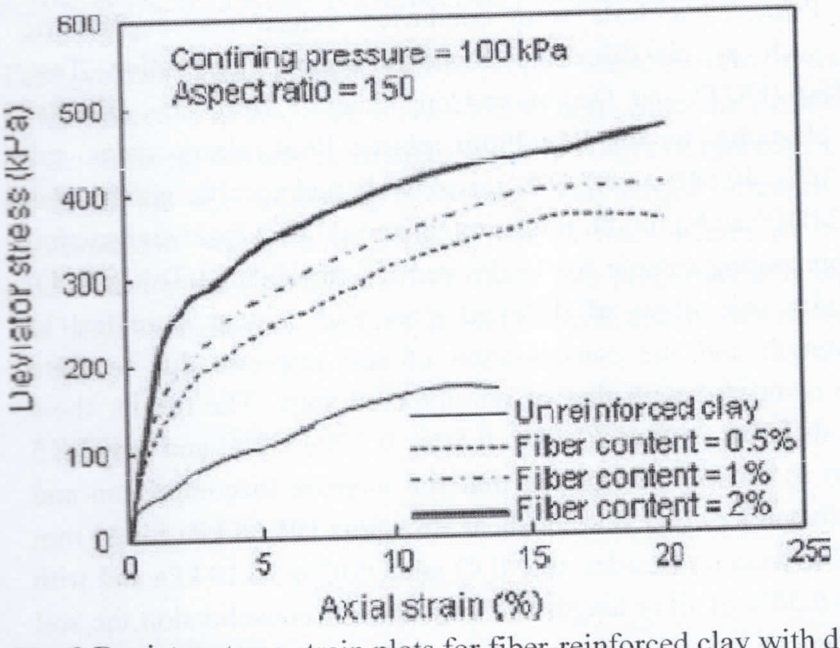


Fig. 3 Deviator stress-strain plots for fiber-reinforced clay with different fiber contents (aspect ratio = 150 and confining pressure = 100 kPa)

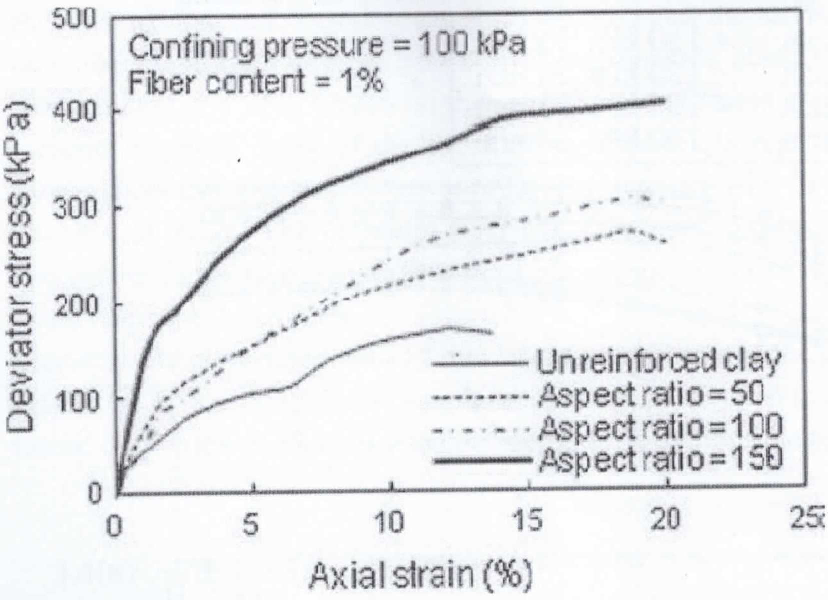


Fig. 4 Deviator stress-strain plots for fiber-reinforced clay with different aspect ratios (fiber content = 1 % and confining pressure = 100)2.2 Stress-Strain Response in Direct Shear Tests

Has San (2010) in this research the soil samples are taken about 4 indepth from ground surface at KampungBeruas, Pekan. The tests were conducted todetermine engineering properties of soil samples such as classification, StandardProctor Compaction Test, Unconsolidated Undrained Test (UUT) and OedomoterConsolidation Test. The soil was classified as clay with high plasticity, having liquidlimit, plastic limit, plastic index and shrinkage limit of 72.0%, 31.36%, 40.64%, and7.86% respectively and specific gravity was *2.51.* Maximum dry density (MDD) andoptimum moisture content (OMC) from compaction test were used as the basis inpreparing sample for Undrained Unconsolidated Test (UUT). The soil samplesreinforced with coir fibres of different sizes and content were test to determine thecompaction, strength and the consolidation of soil response due to fibre inclusion andthe results were compared with that of unreinforced soils. The results show thataddition of coir fibre with different content *(0.25%, 0.50%, 0.75%,* 1.0%) and length(15 mm, 25 mm, 35 mm, 45 mm) as random reinforcing material increase thecompaction and strength of soft soil. The effectiveness of coir fibre in shear strengthis 105.68 kPa for 35 mm in fibre length and *0.50%* in fibre content. Besides, theMDD and OMC is 16.10 kPa and with 13% which is from 45 mm at *0.50%* of fibre length and content. For consolidation the soil after treated produced the lessconsolidation and decreases the void ratio of the soil samples in stabilized soft soil.

U.K.Das et al (2015) used the concept of waste tyres in civil construction works which is slowly gaining ground as one of the methods of disposal of waste tyres. In their study an attempt was made to explore the potential of these tyre ropes as reinforcement members in Reinforced Earth Retaining Walls.

CHAPTER 3

TEST PROGRAMME

First of all the classification of soil will be done to determine the type of soil. For the classification the following tests are being carried out-

1. Specific Gravity Test
2. Sieve Analysis Test
3. Standard Proctors Test
4. Liquid Limit Test
5. Plastic Limit Test

After the soil classification we move on to the next part of the experiment where we will mix soil with coir at different amount and length. Before moving on, we will determined the diameter of coir ropes. Then we will mix coir with soil at different combination of amount and length. First of all, Unconfined Compressive Strength Test will be carried out for 2 sets and 2 variables. The coir length that we will take is ½ inch and 1 inch whereas the amount of coir (% by weight) taken will be 0.5% and 1%. Then Direct Shear Test will be carried out. Two sets of experiments were carried out for ½ inch and 1 inch coir length for coir amount of 0.25%, 0.5%, 0.75% and 1% respectively to obtain the perfect blend of soil and coir.

Then we move on to the next part of project where recycled tyres will be used as anchors for soil. Dimension of tyre rope is (12.45*6.1) mm. Since no particular test method is developed for determining the tensile strength and grip length of tyre ropes, we try to develop a method to determine the following properties. For tensile strength test, the diameter of the reinforcement bar upon which tyre rope is fixed which we will take is 20mm .The test procedure for the determination of these two properties is being described in next chapter. The bond strength between the tyre and soil will also be determined for future references.

CHAPTER 4

TEST PROCEDURES

INDEX PROPERTIES OF SOIL

Index properties are the properties of soil that help in identification and classification of soil. These properties are generally determined in the laboratory. In situ density and relative density require undisturbed sample extraction while other quantities can be determined from disturbed soil sampling. The following are the Index Properties of soil.

4.1. Specific Gravity

4.2 Particle size distribution

4.3. Consistency limits

4.4 Compaction tests of soil

After determining the index properties we carried out the following tests-

4.5Unconfined compression test

4.6 Direct shear test

4.7 Tensile strength of tyre rope

4.8 Grip length test

4.1.Test Procedure for determining the Specific Gravity.

The empty bottle is cleaned with kerosene and is dried and then the weight of the empty bottle with stopper (W_1) is determined and recorded. 20 gm of oven soil sample is taken and is transferred into the bottle carefully using a paper funnel. The weight of the bottle along with the soil sample (W_2) is determined and recorded. The rest of bottle is filled with distilled water and then put in a desiccator to remove the air bubbles and the weight of the bottle and the contents (W3) is determined and recorded. The bottle is then emptied and thoroughly cleaned and is filled with only distilled water and the weight is determined and recorded (W4). The same process is repeated for 2 to 3 times, to take the average reading of it.

4.2. Test Procedure for Particle size distribution (Sieve Analysis Test)

Oven dried sample of soil that weighs about 1000 g is taken (this is normally used for soil samples the greatest particle size of which is 4.75 mm). If the soil particles are lumped or conglomerated then the lumps are crushed using the pestle and mortar. The mass of sample

W_t (g) is accurately determined and recorded. A stack of sieves are prepared. Sieves having larger opening sizes are placed above the ones having smaller opening sizes. The sequence is as follows – 4.75mm, 2mm, 1mm, 0.600mm, 0.425mm, 0.300mm, 0.212mm, 0.150mm, 0.075mm and the pan at the bottom.

4.3. Test Procedure for Consistency limits

4.3.1. Test for Liquid Limit

Liquid limit (W_L) is defined as the arbitrary limit of water content at which the soil is just about to pass from the plastic state to the liquid state. At this limit, the soil possesses a small value of shear strength, losing its ability to flow as a liquid. In other words, the liquid limit is the minimum moisture content at which the soil tends to flow as a liquid. The liquid limit test was carried out using Casagrande apparatus as per Indian standard code of soil IS: 2720 - Part 5, 1985. For this test about 120 gm of the oven dried sample passing 425 micron was taken.

4.3.2. Test for Plastic Limit

The plastic limit test was carried out as per the IS code of soil IS: 2720 - Part 5, 1985. About 20 gm of the sample was taken mixed thoroughly with the water till the soil mass becomes plastic enough to be easily mould with fingers. Then a ball of about 8 gm was made using this plastic soil and rolled between the fingers to a diameter of about 3 mm. Then after observing no cracks in the thread it was kneaded together to a uniform mass and rolled again. The process of alternate rolling kneading continues until the cracks start appearing in a thread of 3 mm diameter. Then it is kept for water content determination in the oven. The water content corresponding to such a thread of soil is known as plastic limit. The average of the three such values was taken as plastic limit of the given soil.

4.4. Test Procedure for Light Compaction Test or Standard Proctor's Test

About 2.5 Kg. of soil is taken and water is added to bring its moisture content to about 4 % (4% in case of coarse grained soils and 8% in case of fine grained soils) with the help of graduated cylinder. The mould with base plate is attached to its base and is weighed to the nearest 1 gm (M_1) and recorded. The extension collar is then attached to the mould.The moist soil in the mould is compacted in three equal layers, each layer being given 25 blows from the 2.6 Kg rammer dropped from a height of 310 mm above the soil.The extension is removed and then the compacted soil is levelled off carefully to the top of the mould by means of a straight edge or blade.Then the mould and soil is weighed to the nearest 1 gm. (M_2) and recorded.The soil is removed from the mould and a representative soil sample is obtained for water content determination. The above steps are repeated after adding suitable amount of water to the soil in an increasing order.

4.5 Test Procedure for Unconfined Compression Test

Diameter of coir =0.15 mm
Diameter of mould = 10 cm
Height of mould = 20 cm
Volume of mould = 1571 cubic cm
Mass of soil sample taken = 2700 gm (approx)

Firstly, oven dried soil passing through 2mm sieve is taken. The test is being conducted at optimum moisture content (O.M.C) which is 18% for this soil specimen. Soil sample is then mixed with coir of different length and amount (% by weight) of soil. Water is then added to the specimen and mixed thoroughly for around 2-3 minutes to ensure uniform mixing of sample. After mixing, the sample is carefully placed in polythene bag for 24 hrs so that uniform mixing of coir and soil sample takes place.

After 24 hours, the sample is taken out and compacted into mould in 5 layers and 25 numbers of blows for each layer. After compaction, the sample is put under the unconfined compression machine. One thing must be ensured that sample is put at the centre of the machine so that load is applied uniformly on the sample. Once the sample is put on the machine, power is turned on. Once the contact is being made, the compression dial reading and proving ring is calibrated to zero. Then the test is started and readings are taken at 20 intervals and proving ring readings are noted down.

4.6 Test Procedure for Direct Shear Test

Diameter of coir =0.15 mm

We take 232g of soil sample and mix it with 18% of water. Then we compress it in three layers in the mould which is available in the direct shear test apparatus. Compression of the soil is carried out with the help of the small tampering rod. The dimensions of the mould are as follows- 6cm width, 6cm breadth, and 4cm height. Once the compaction is done we place the lid on top of the mould and place it in the direct shear test apparatus. We did the test with three different load or normal stress which is as follows- 0.5 kg/sq. cm, 1.0 kg/sq. cm and 1.5 kg/sq.cm. We used gear A with an rpm of 1.25.

Procedure for direct shear test of soil sample along with coir mixed with the soil. For this we use different percentage of coir and different lengths. We used 0.25%, 0.5%, 0.75%, and 1% by weight of soil and lengths one and half inch.

For 0.25% by weight of soil amount of coir and coir length of half inch we calculated the amount of coir to be taken which came out to be 0.58g and mixed it with 231.42 g of soil sample properly. Then we compact it into the mould in three layers with the help of the small tampering rod. Once the soil and mixed coir is compacted into the mould we place the lid of the mould and place it in the direct shear test apparatus and continue the procedure mentioned above with three different normal stresses.

For 0.5% by weight of soil amount of coir and coir length of half inch we calculated the amount of coir to be taken which came out to be 1.16g and mixed it with 230.84 g of soil sample properly. Then we followed the procedure mentioned above with three different normal stresses.

For 0.75% by weight of soil amount of coir and coir length of half inch we calculated the amount of coir to be taken which came out to be 1.74g and mixed it with 230.26 g of soil sample properly. Then we followed the procedure mentioned above with three different normal stresses.

For 1% by weight of soil amount of coir and coir length of half inch we calculated the amount of coir to be taken which came out to be 2.32g and mixed it with 229.68 g of soil sample properly. Then we followed the procedure mentioned above with three different normal stresses.

4.7 Test Procedure for determining the tensile strength of tyre rope

Firstly a tyre rope of approx 40 cm length (25 cm gauge length) is taken and is passed through a table with hole of dimension equal to the dimension of tyre rope. The portion of rope placed above the table is tied to a steel bar placed in concrete blocks. The bar and concrete block are tied properly so the there is no lateral movement of bar on concrete block. The portion of tyre below is attached to a hanger where loads are applied.

Before application of load, a reference point is marked and after application of loads, the displacements are measured corresponding to the reference point. Along with displacements, its width and thickness are also measured using sliding calipers. Data is collected and after calculation stress-strain curve is plotted.

4.8 Test Procedure for determining the grip length of tyre rope.

Firstly, mould of 10 cm diameter and 20 cm height is taken for the preparation of sample. The mould is placed on a table of thickness 3 cm. A tyre rope of dimension (12.45*6) mm and length 25 cm is taken and marked with pen for reference. Then a cardboard of diameter equal diameter of mould is taken and along its centre line a hole of dimension equal to that of tyre rope is cut off. Then sample is prepared first without coir and then using coir of ½ inch length and 0.5% by weight. The amount of soil taken is calculated as

W= Volume of mould * density

= 1570 * 1.67

= 2.89 kg

The soil is compacted in the mould in 5 layers with 25 number of blows in each layer with the tyre rope being placed at the centre of mould. The upper end of the rope is made free while the lower part is tied with a hanger where the loads will be applied. Before the commencement of test, the weight of hanger and other loads were taken. Before starting the experiment, reference point is marked and with the help of it the extension of rope is measured. Verniercalliper is required to measure the change in thickness and width of rope.

Now the loads are applied one after another and corresponding extension are noted down. The experiment is continued till the rope slips through the mould.

CHAPTER 5

TEST RESULTS

5.1Specific Gravity test

OBSERVATION NUMNER.	I	II
Weight of density bottle (W1) (g)	32.44	32.44
Weight of density bottle + dry soil (W2) (g)	42.44	42.50
Weight of density bottle + dry soil + water (W3) (g)	86.86	86.85
Weight of density bottle + water (W4) (g)	80.62	80.60
Specific Gravity of soil =(W2-W1)/(W2-W1)-(W3-W4)	2.659	2.66
Average of the values	2.66	

Table 5.1.Specific Gravity Test

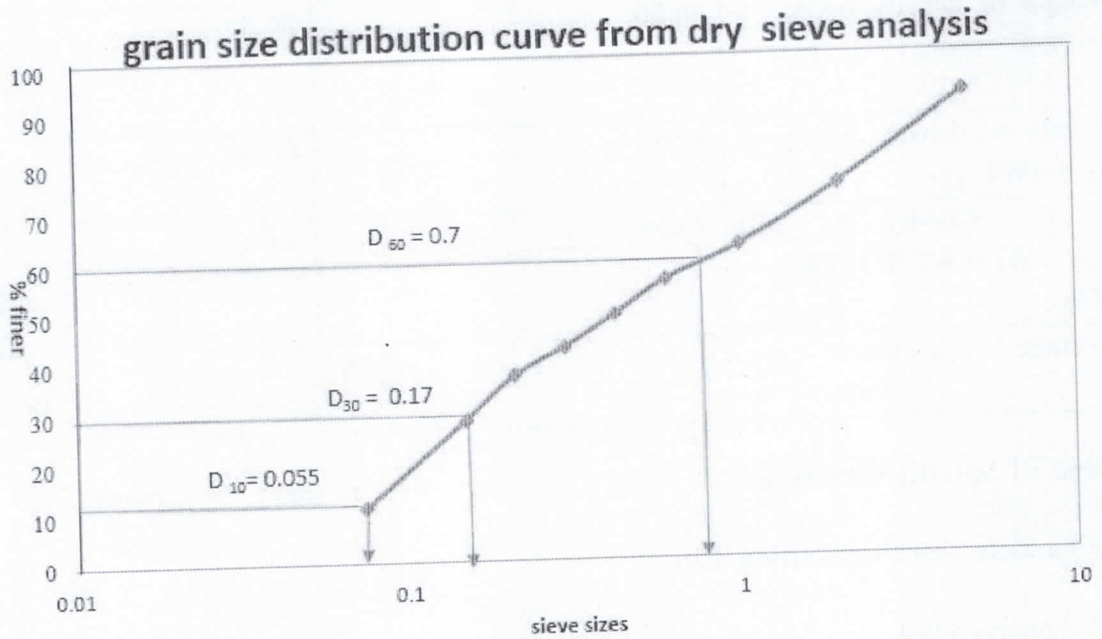
5.2 Particle Size Distribution Test

Sieve analysis test

IS Sieves	Particle Size (mm)	Mass Retained (g)	% Retained	Cummulative % Retained	Cummulative % Finer (d)
4.75	4.75mm	82.22	7.51	7.51	92.49
2	2mm	197.28	18	25.5	74.5
1	1mm	131.38	12	37.51	62.49
600	0.600mm	73.08	6.68	44.19	55.81
425	0.425mm	73.76	6.74	50.93	49.07
300	0.300mm	70.38	6.43	57.36	42.64
212	0.212mm	59.85	5.47	62.83	37.17

150	0.150mm	96.25	8.8	71.63	28.37
75	0,075mm	189.95	17.35	88.98	11.02
PAN		120.62	11.02	100	0
		Total=1094.77			

Table 5.2.Sieve Analysis Test



Graph 5.1.Grain size distribution curve from sieve analysis test.

$C_u = D_{60} / D_{10} = (0.7/ 0.075) = 12.96$

$C_c = D_{30}^2 / (D_{60} \times D_{10}) = = 0.16^2 / (O.075 \times 0.7) = 0.7$

5.3 Plummet balance test

Mean diameter = k x√(Ze/T)

Temperature = 29°C

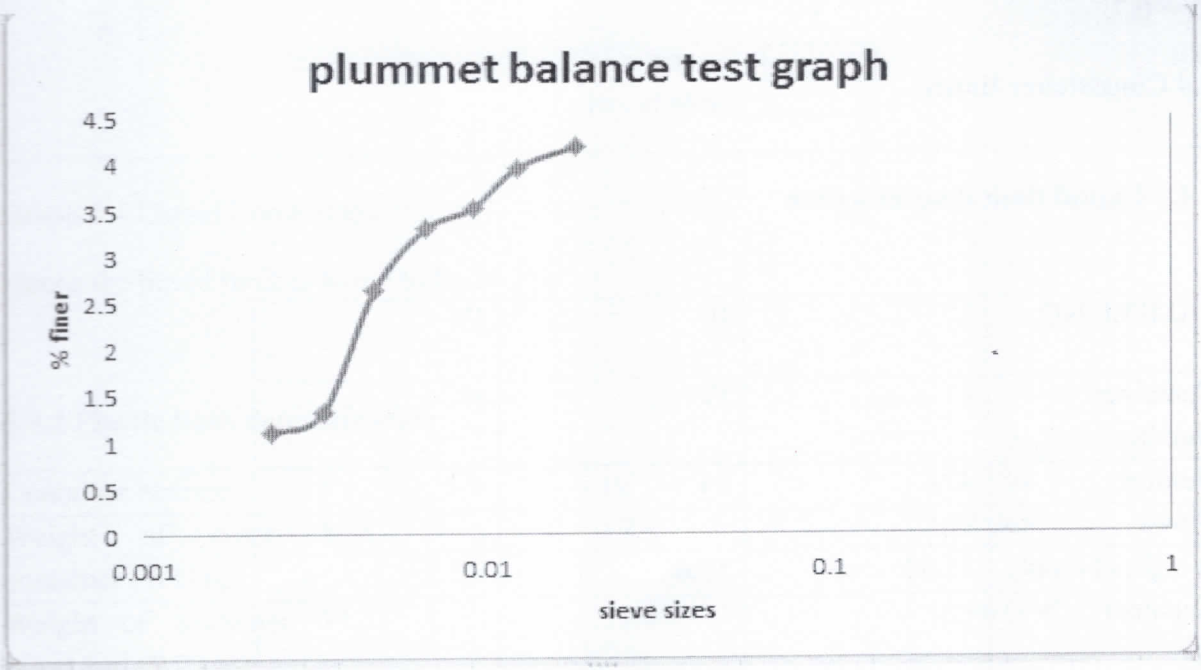
Effective Length ,Ze = 15.4cm

Specific Gravity of soil = 2.66

k= 0.0122

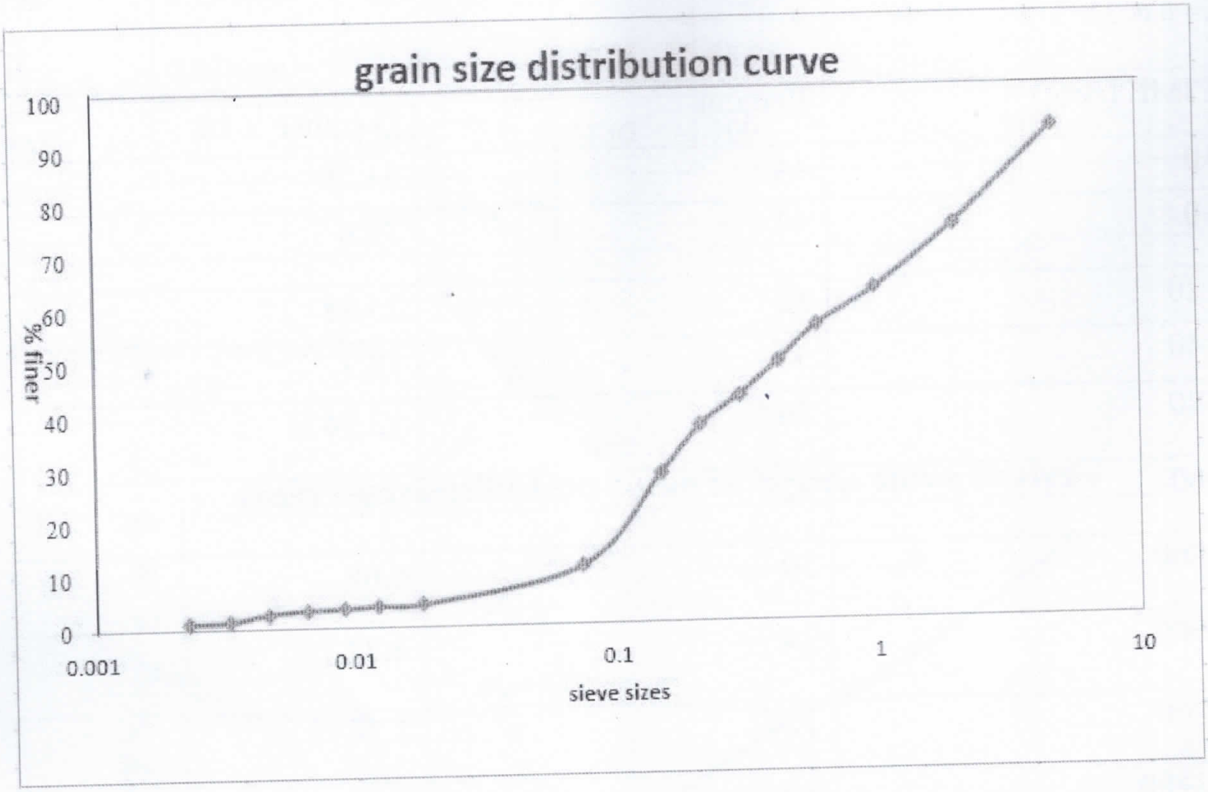
TIME (secs)	Percent	D (mm) x 10^{-3}
30	44	51.76
60	44	36.6
120	42	25.88
240	38	18.3
480	36	12.94
960	32	9.15
1800	30	6.68
3600	24	4.72
7200	12	3.34
14400	10	2.36

Table 5.3.Plummet Balance Test.



Graph 5.2.Plummet Balance test graph

Combining both the graphs



Graph 5.3.Combining both the graphs of sieve analysis and plummet balance test.

$C_u = 12.96$

$C_c = 0.7$.

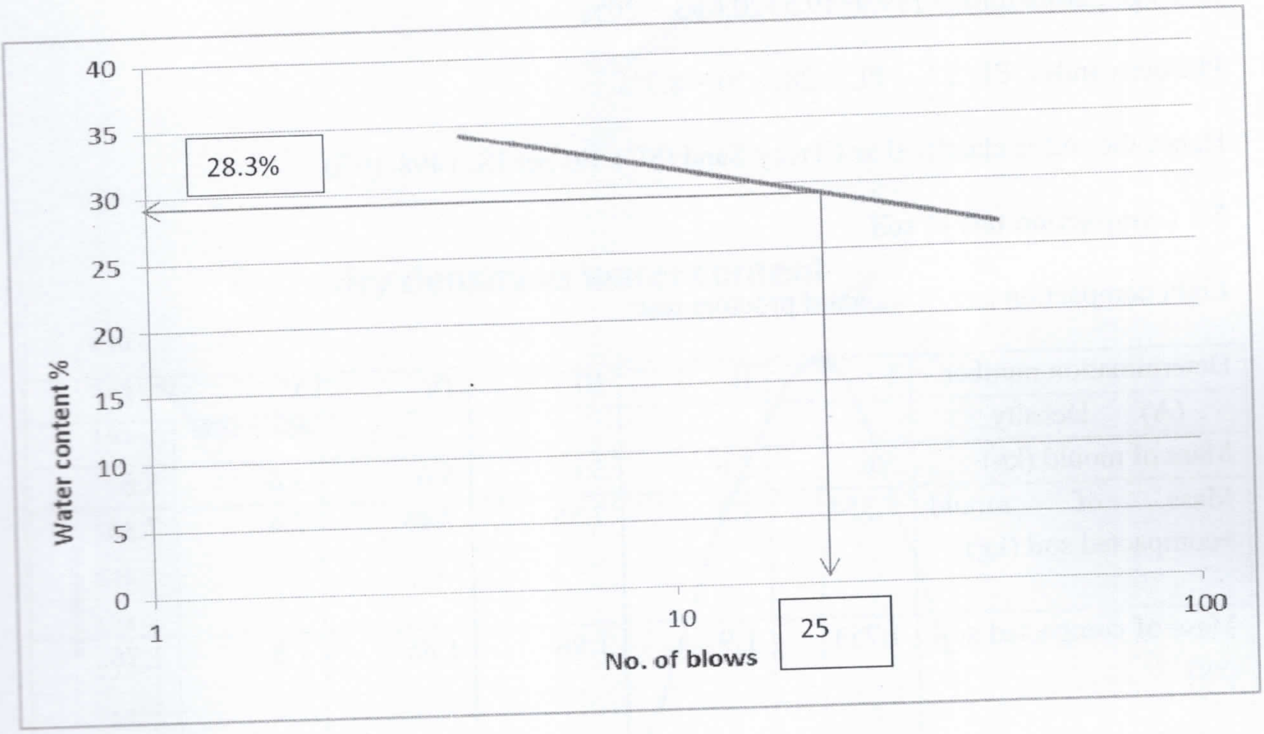
5.4 Consistency limits

5.4.1 Liquid limit determination

SAMPLE NO.	I	II	IV
Container Number	1	IV	N
Number of Blows	42	24	4
Weight of empty container (W1) (g)	11.84	17.6	22
Weight of container + wet soil (W2) (g)	27	31.99	33.14

Weight of container + dry soil (W3) (g)	23.8	28.8	30.3
Water content (w %)= (W2-W3)/(W3-W1) x 100 %	26.75	28.5	34.22

Table 5.4.Liquid Limit Test



Graph 5.4.Liquid Limit graph

Hence the liquid limit is found to be 28.3%

5.4.2 Plastic limit determination

Container Number	I	IV	4
Weight of empty container (W1) (g)	11.8	17.6	16.8
Weight of container + wet soil (W2) (g)	14.33	21.65	18.96
Weight of container + dry soil (W3) (g)	13.91	20.99	18.59

Water content (w %)= (W2-W3)/(W3-W1) x 100 %	19.9	19.5	20.6
Average of the plastic limit values	20		

Table 5.5.Plastic Limit test

Average plastic limit = (19.9+19.5+20.6)/3 = 20%

Plasticity index, PI= LL – PL = 28.3-20 = 8.3%

Hence the soil is classified as Clayey Sand (SC). (as per IS: 1498-1970.

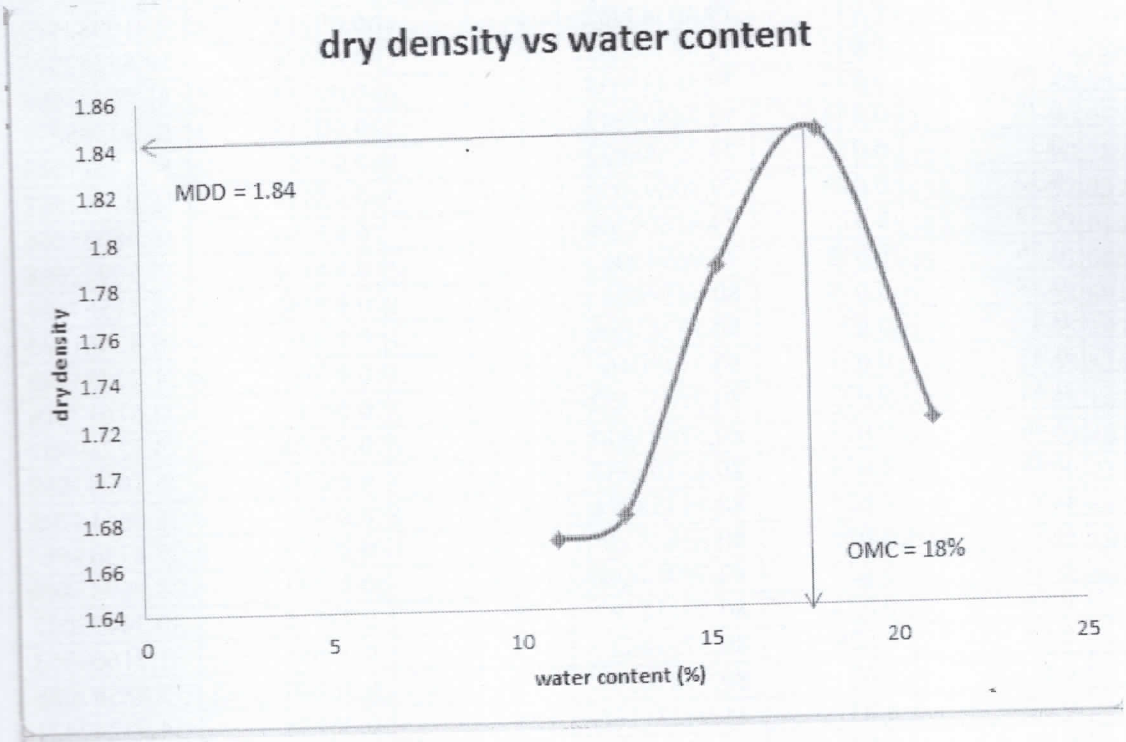
5.5 Compaction test of soil

Light compaction test or standard proctors test

Determination number	I	II	III	IV	V	VI
(A) Density						
Mass of mould (kg)	5.6	5.6	5.6	5.6	5.6	5.6
Mass of mould +compacted soil (kg)	7.354	7.5	7.56	7.45	7.4	7.36
Mass of compacted soil (kg)	1.754	1.9	1.96	1.85	1.8	1.76
Bulk density , W/V (g/cm3)	1.85	2.01	2.076	1.96	1.9	1.86
Dry density	1.74	1.82	1.848	1.735	1.65	1.6
(B) Water content						
Container No.	4	1	3	22	IV	WI-1
Weight of empty container (W1) (g)	16.8	11.8	17	17.5	17.6	19.03
Weight of container + wet soil (W2) (g)	36.7	29.5	35.5	42.1	37	39.41

Weight of container + dry soil (W3) (g)	35.43	27.86	33.51	39.28	34.5	36.52
Water content (w %)= (W2-W3)/(W3-W1) x 100 %	6.8	10.2	12.05	12.95	14.9	16.52

Table 5.6.Light compaction test or standard proctor's test.



Graph 5.5.Light Compaction test

OMC =18 %

MDD = 1.84 g/cm^3

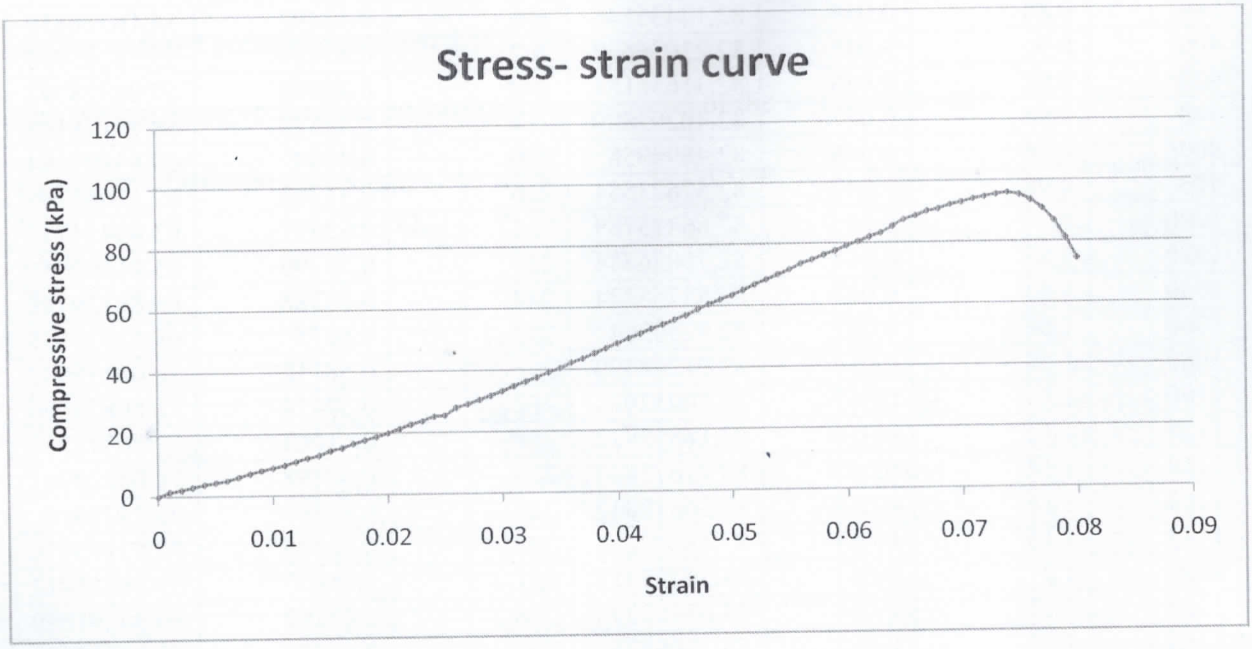
5.6 Unconfined compression test 1

Here we are going to find the unconfined compression of the soil sample only.

CDR L.C= 0.001 cm	Deflection D=CDR* L.C (cm)	Strain S= D/L	Area Ac= Ao/(1-S) (cm sq.)	Proving ring reading (PRR)	Axial load P= 0.00227*PRR (kN)	Compression stress C= P/Ac (kPa)
0	0	0	78.53	0	0	0
20	0.02	0.001	78.60860861	5	0.01135	1.443862218
40	0.04	0.002	78.68737475	7	0.01589	2.019383675
60	0.06	0.003	78.7662989	10	0.0227	2.881943206
80	0.08	0.004	78.84538153	13	0.02951	3.742768369
100	0.1	0.005	78.92462312	15	0.03405	4.314242964
120	0.12	0.006	79.00402414	17	0.03859	4.884561314
140	0.14	0.007	79.0835851	21	0.04767	6.027799567
160	0.16	0.008	79.16330645	25	0.05675	7.168725328
180	0.18	0.009	79.2431887	28	0.06356	8.020878645
200	0.2	0.01	79.32323232	31	0.07037	8.871297593
220	0.22	0.011	79.40343782	34	0.07718	9.719982172
240	0.24	0.012	79.48380567	38	0.08626	10.85252515
260	0.26	0.013	79.56433637	42	0.09534	11.98275563
280	0.28	0.014	79.64503043	45	0.10215	12.82565898
300	0.3	0.015	79.72588832	50	0.1135	14.23627913
320	0.32	0.016	79.80691057	53	0.12031	15.07513562
340	0.34	0.017	79.88809766	58	0.13166	16.48055266
360	0.36	0.018	79.9694501	62	0.14074	17.59922068
380	0.38	0.019	80.0509684	66	0.14982	18.71557621
400	0.4	0.02	80.13265306	70	0.1589	19.82961925
420	0.42	0.021	80.2145046	75	0.17025	21.22434102
440	0.44	0.022	80.29652352	80	0.1816	22.61617216
460	0.46	0.023	80.37871034	84	0.19068	23.72269961
480	0.48	0.024	80.46106557	89	0.20203	25.10903858
500	0.5	0.025	80.54358974	90	0.2043	25.36514708
520	0.52	0.026	80.62628337	99	0.22473	27.8730447
540	0.54	0.027	80.70914697	103	0.23381	28.96945499
560	0.56	0.028	80.79218107	108	0.24516	30.34452057
580	0.58	0.029	80.8753862	113	0.25651	31.71669553
600	0.6	0.03	80.95876289	118	0.26786	33.08597988
620	0.62	0.031	81.04231166	124	0.28148	34.73247421
640	0.64	0.032	81.12603306	129	0.29283	36.09568827
660	0.66	0.033	81.20992761	134	0.30418	37.45601172
680	0.68	0.034	81.29399586	140	0.3178	39.09267796
700	0.7	0.035	81.37823834	145	0.32915	40.44693111
720	0.72	0.036	81.4626556	151	0.34277	42.07694894
740	0.74	0.037	81.54724818	156	0.35412	43.4251318
760	0.76	0.038	81.63201663	162	0.36774	45.04850121
780	0.78	0.039	81.7169615	168	0.38136	46.66840188
800	0.8	0.04	81.80208333	174	0.39498	48.28483382
820	0.82	0.041	81.88738269	180	0.4086	49.89779702
840	0.84	0.042	81.97286013	185	0.41995	51.23037056
860	0.86	0.043	82.0585162	191	0.43357	52.83668534

880	0.88	0.044	82.14435146	196	0.44492	54.16318859
900	0.9	0.045	82.23036649	202	0.45854	55.76285496
920	0.92	0.046	82.31656184	207	0.46989	57.08328792
940	0.94	0.047	82.40293809	214	0.48578	58.95178148
960	0.96	0.048	82.4894958	220	0.4994	60.54104164
980	0.98	0.049	82.57623554	226	0.51302	62.12683306
1000	1	0.05	82.66315789	231	0.52437	63.43454731
1020	1.02	0.051	82.75026344	237	0.53799	65.01369031
1040	1.04	0.052	82.83755274	244	0.55388	66.86339488
1060	1.06	0.053	82.9250264	250	0.5675	68.43531135
1080	1.08	0.054	83.01268499	256	0.58112	70.00375907
1100	1.1	0.055	83.1005291	262	0.59474	71.56873806
1120	1.12	0.056	83.18855932	269	0.61063	73.40312237
1140	1.14	0.057	83.27677625	274	0.62198	74.68828983
1160	1.16	0.058	83.36518047	280	0.6356	76.2428626
1180	1.18	0.059	83.45377258	285	0.64695	77.52195976
1200	1.2	0.06	83.54255319	291	0.66057	79.06988412
1220	1.22	0.061	83.6315229	296	0.67192	80.34291099
1240	1.24	0.062	83.7206823	302	0.68554	81.88418693
1260	1.26	0.063	83.81003202	307	0.69689	83.15114351
1280	1.28	0.064	83.89957265	315	0.71505	85.22689418
1300	1.3	0.065	83.98930481	323	0.73321	87.29801987
1320	1.32	0.066	84.07922912	328	0.74456	88.55457023
1340	1.34	0.067	84.1693462	334	0.75818	90.07792436
1360	1.36	0.068	84.25965665	337	0.76499	90.78959379
1380	1.38	0.069	84.35016112	342	0.77634	92.03776137
1400	1.4	0.07	84.44086022	346	0.78542	93.01421113
1420	1.42	0.071	84.53175457	350	0.7945	93.9883484
1440	1.44	0.072	84.62284483	353	0.80131	94.69192411
1460	1.46	0.073	84.71413161	356	0.80812	95.39376544
1480	1.48	0.074	84.80561555	358	0.81266	95.82620145
1500	1.5	0.075	84.8972973	356	0.80812	95.18795365
1520	1.52	0.076	84.98917749	350	0.7945	93.48249077
1540	1.54	0.077	85.08125677	340	0.7718	90.71328155
1560	1.56	0.078	85.17353579	325	0.73775	86.61728002
1580	1.58	0.079	85.2660152	305	0.69235	81.19882211
1600	1.6	0.08	85.35869565	280	0.6356	74.46224373

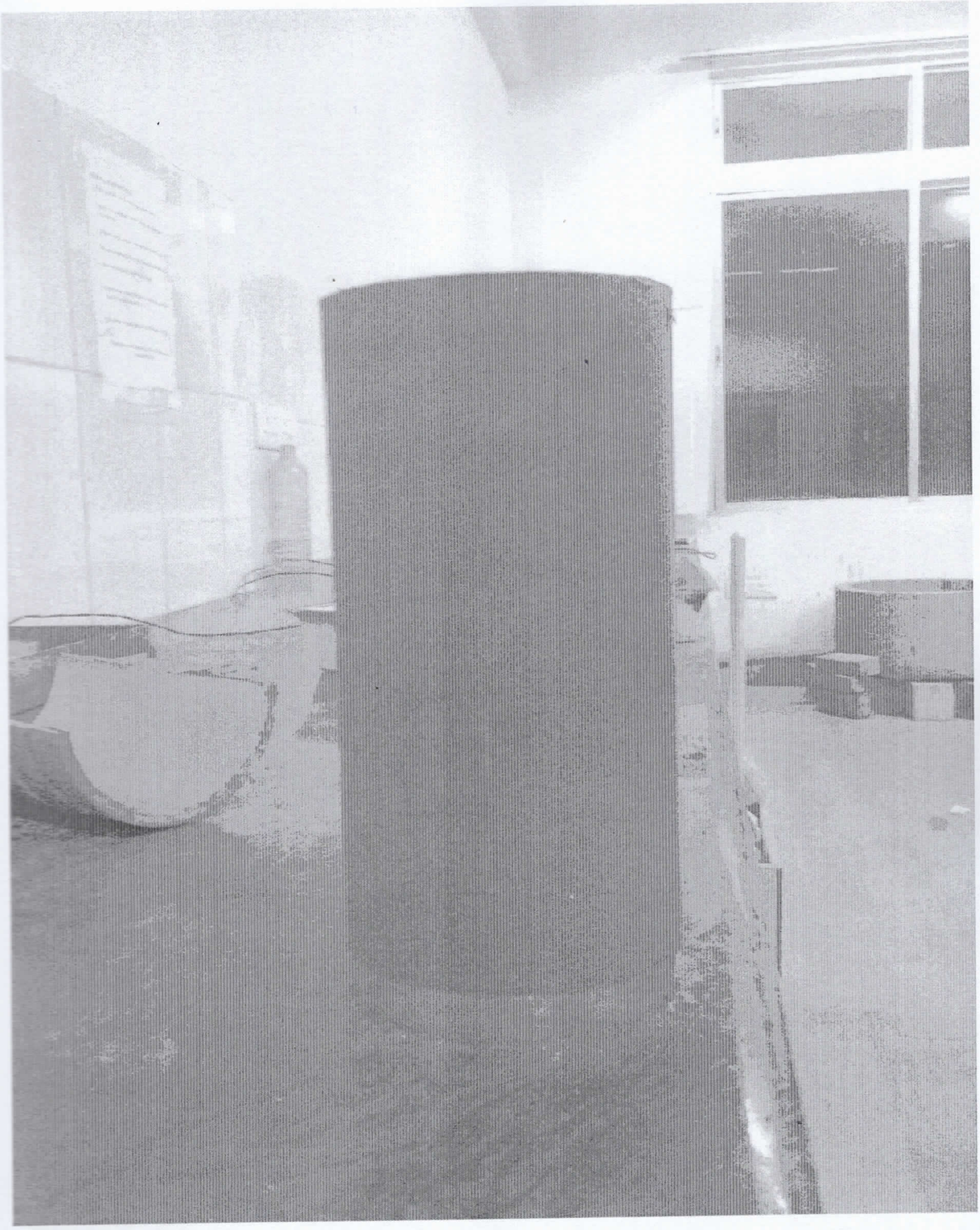
Table 5.7.UCS for soil sample only



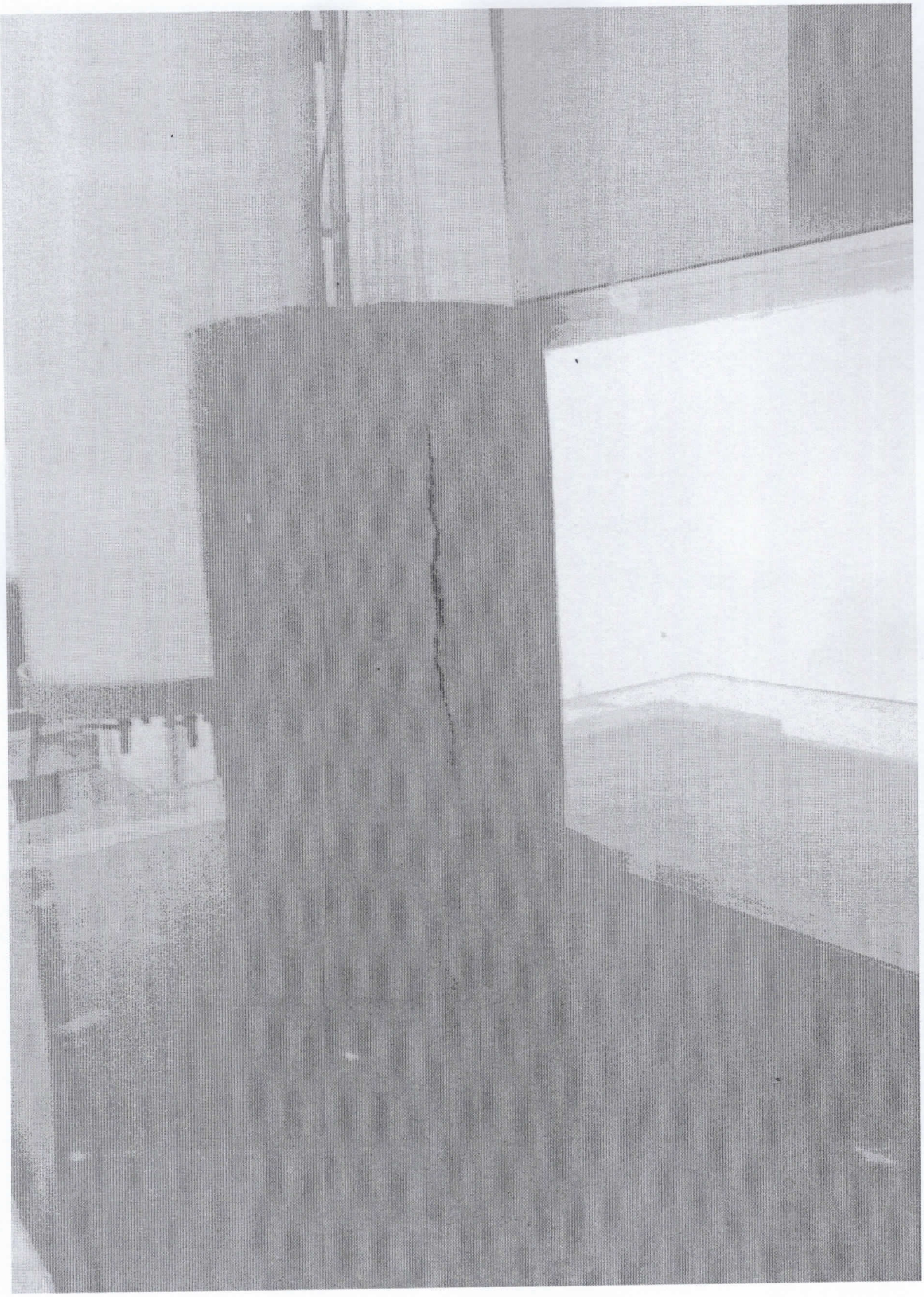
Graph 5.6. This is the graph between strain and compression stress.

Cu= 95.826 kPa

Su = 47.913 kPa



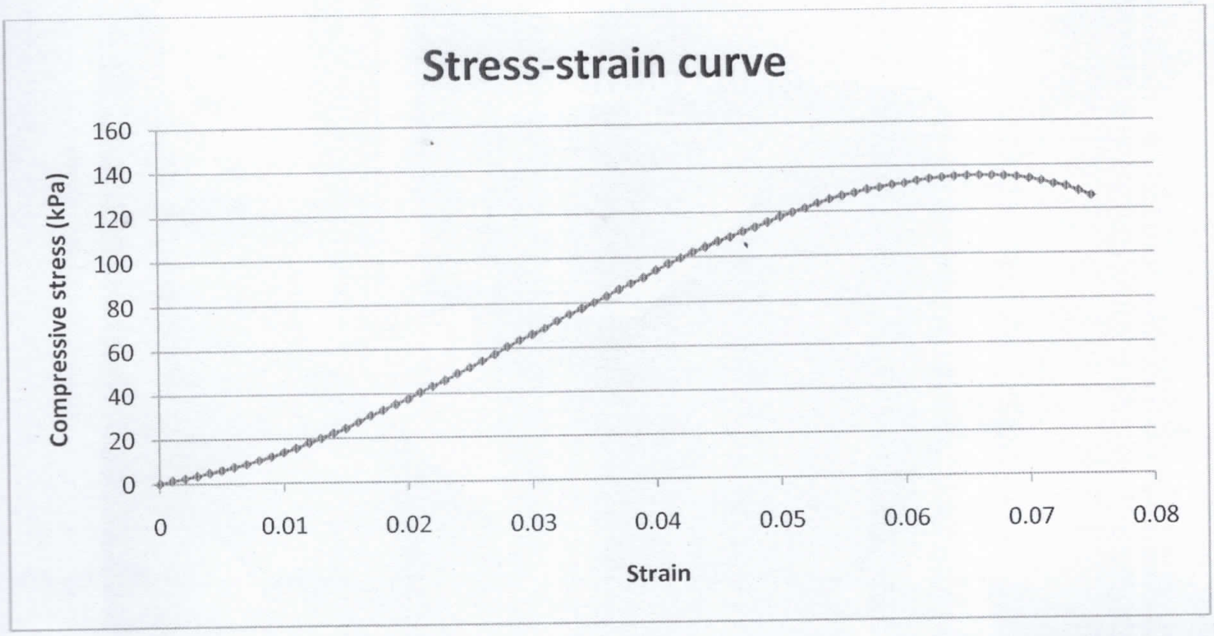
PICTURE 1.Sample (only soil) before putting it into the machine.



PICTURE 2.Sample (only soil) after taking it out of the machine.

5.6 Unconfined compression test 2

Here we are going to find out the unconfined compression of the soil along with coir mixed with the sample. For this test we take 3.0kg of soil and 28.79 g of coir (1% by weight of soil). The coir pieces have a length of half inch.



Graph 5.7.This is the graph between strain and compression stress

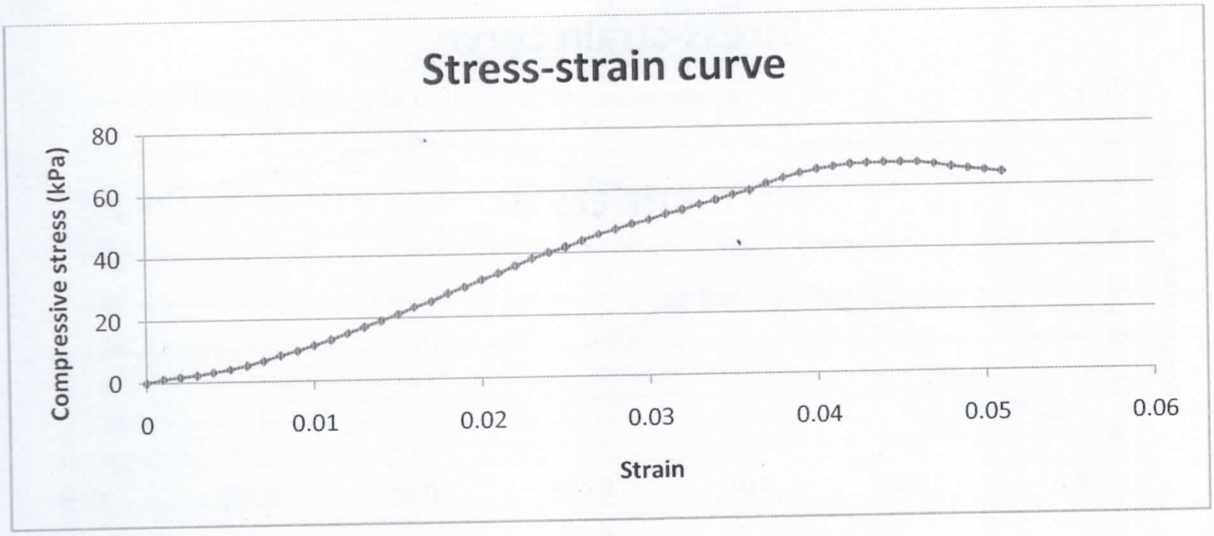
Cu = 134.904 kPa

Su = 67.452 kPa

PICTURE 3.Sample (soil + coir) after taking it out of the machine.

5.6 Unconfined compression test 3

Here we are going to find out the unconfined compression for the soil sample along with coir mixed with the sample. Here we use 0.5% by weight of the soil sample and coir length half inch.



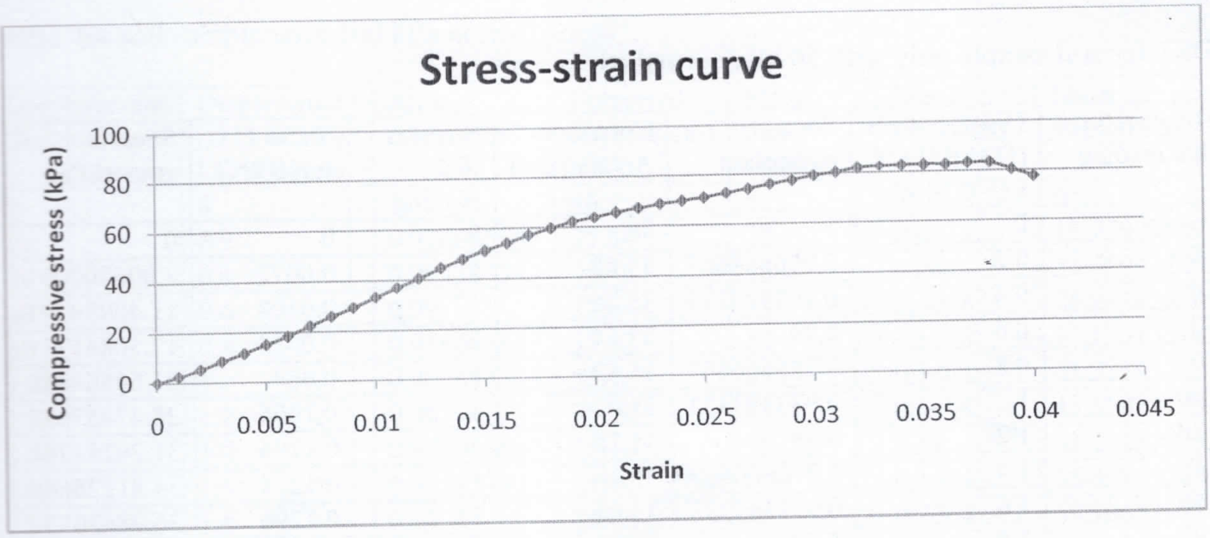
Graph 5.8.This graph shows the curve between strain and compression stress.

Cu = 67.427 kPa

Su = 33.713 kPa

5.6 Unconfined compression test 4

Here we are going to find out the unconfined compression for the soil sample along with coir of 1% by weight of the soil sample and coir length one inch.



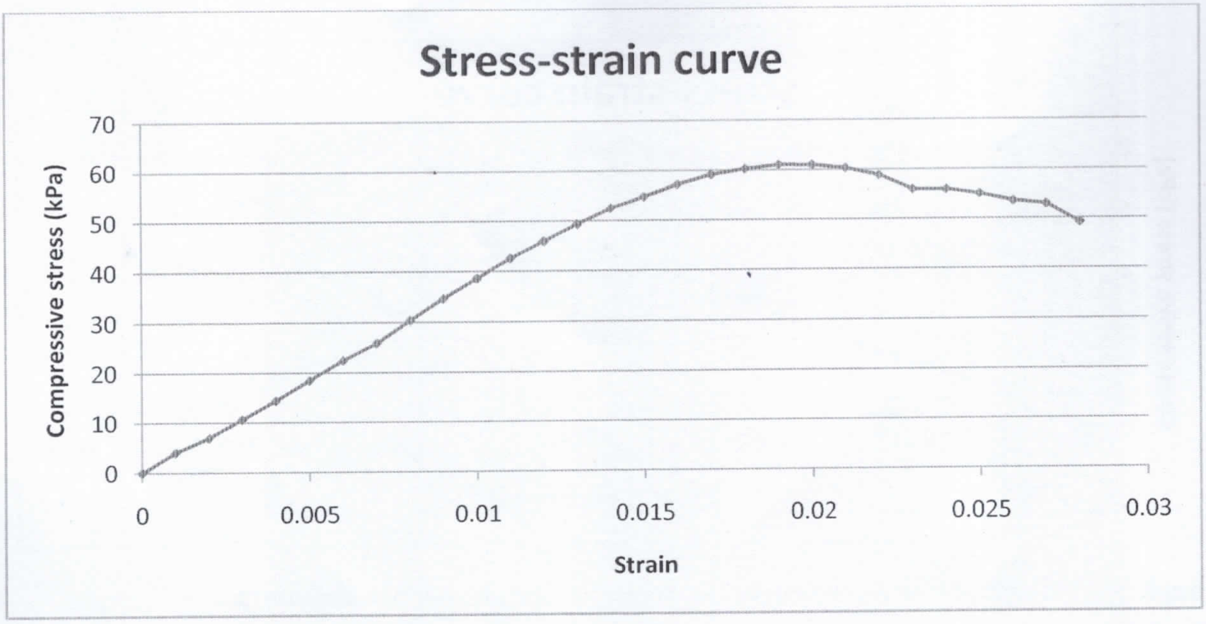
Graph 5.9.This graph shows the curve between strain and compression stress.

Cu = 83.423 kPa

Su = 41.711 kPa

5.6 Unconfined compression test 5

Here we are going to find out the unconfined compression for the soil sample along with coir of 0.5% by weight of the soil sample and coir length one inch.



Graph 5.10.This graph shows the curve between strain and compression stress.

Cu = 60.967 kPa

Su = 30.483 kPa

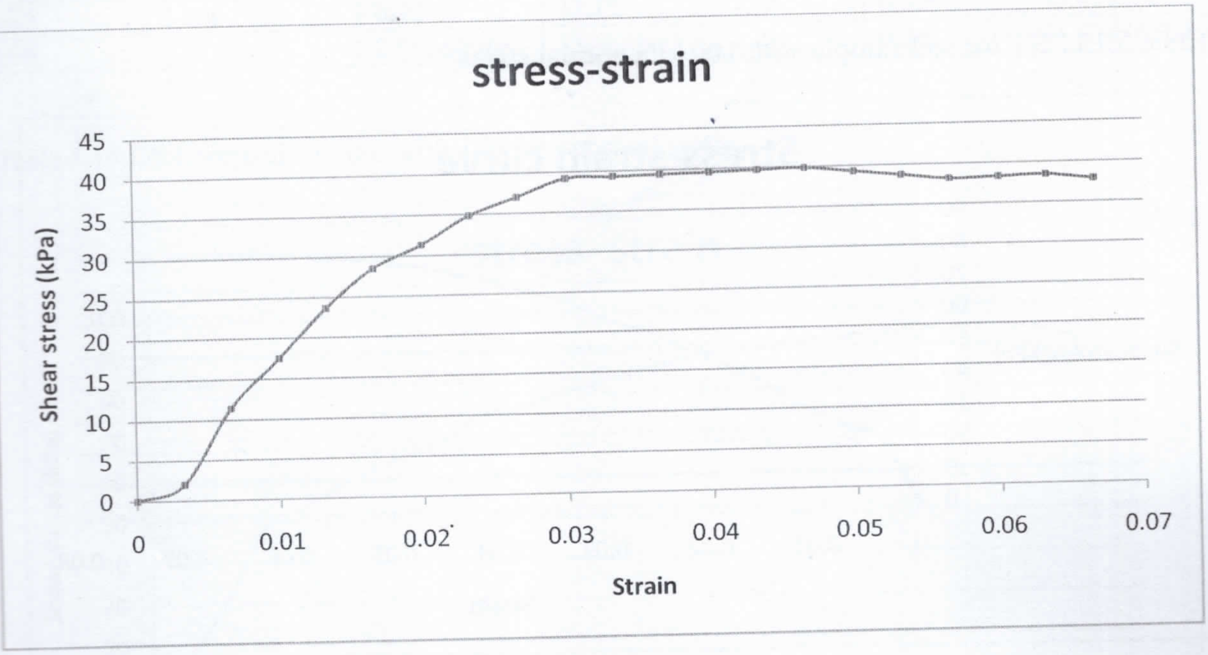
5.7 Direct Shear Test 1

DST for soil sample only with 50 kPa normal stress

Displacement dial reading	Displacement (D.D.R*LC) LC=0.01mm	Area correction	Corrected Area(sq.cm)	Stress dial reading	Shear force(kN)	Shear stress(kPa)
0	0	1	36	0	0	0
20	0.2	0.996666667	35.88	3	0.0072	2.00670000
40	0.4	0.993333333	35.76	17	0.0408	11.40939597
60	0.6	0.99	35.64	26	0.0624	17.50841751
80	0.8	0.986666667	35.52	35	0.084	23.64864865
100	1	0.983333333	35.4	42	0.1008	28.47457627
120	1.2	0.98	35.28	46	0.1104	31.29251701
140	1.4	0.976666667	35.16	51	0.1224	34.81228669
160	1.6	0.973333333	35.04	54	0.1296	36.98630137
180	1.8	0.97	34.92	57	0.1368	39.17525773
200	2	0.966666667	34.8	57	0.1368	39.31034483
220	2.2	0.963333333	34.68	57	0.1368	39.44636678
240	2.4	0.96	34.56	57	0.1368	39.58333333
260	2.6	0.956666667	34.44	57	0.1368	39.72125436
280	2.8	0.953333333	34.32	57	0.1368	39.86013986

300	3	0.95	34.2	56	0.1344	39.29824561
320	3.2	0.946666667	34.08	55	0.132	38.73239437
340	3.4	0.943333333	33.96	54	0.1296	38.16254417
360	3.6	0.94	33.84	54	0.1296	38.29787234
380	3.8	0.936666667	33.72	54	0.1296	38.43416370
400	4	0.933333333	33.6	53	0.1272	37.85714286

Table 5.12.DST for soil sample with 50 kPa normal stress



Graph 5.12.stress strain curve

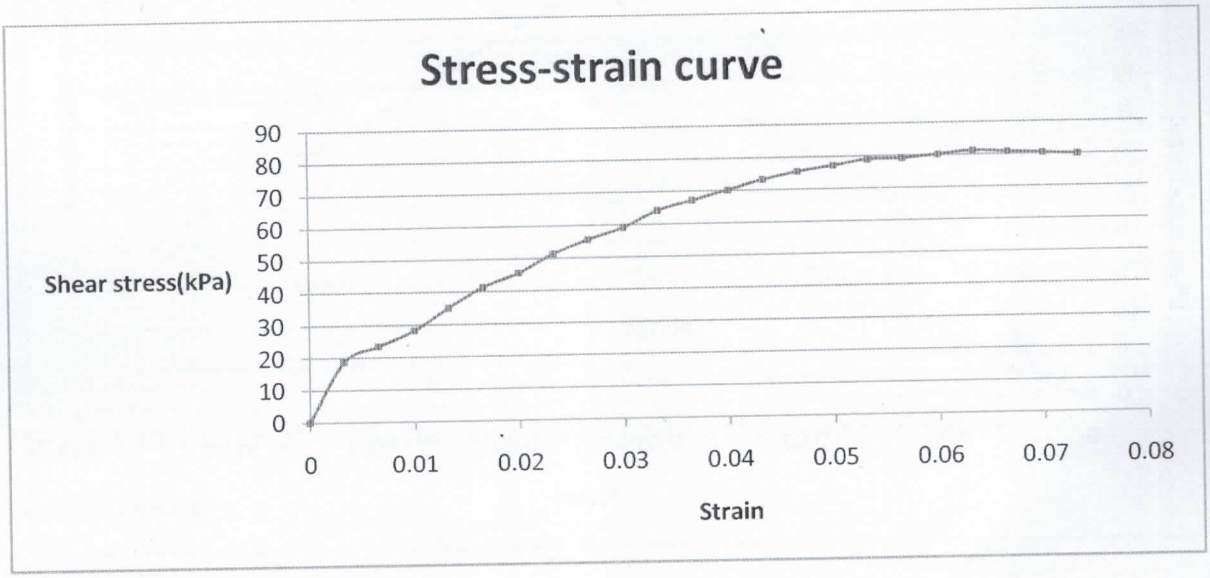
5.7 Direct Shear Test 2

DST for soil sample with 100 kPa normal stress

Displacement dial reading	Displacement (D.D.R*LC) LC=0.01mm	Area correction	Corrected Area(sq.cm)	Stress dial reading	Shear force(kN)	Shear stress(kPa)
0	0	1	36	0	0	0
20	0.2	0.996666667	35.88	28	0.0672	18.72909699
40	0.4	0.993333333	35.76	35	0.084	23.48993289
60	0.6	0.99	35.64	42	0.1008	28.28282828
80	0.8	0.986666667	35.52	52	0.1248	35.13513514
100	1	0.983333333	35.4	61	0.1464	41.3559322
120	1.2	0.98	35.28	67	0.1608	45.57823129
140	1.4	0.976666667	35.16	75	0.18	51.19453925
160	1.6	0.973333333	35.04	81	0.1944	55.47945205
180	1.8	0.97	34.92	86	0.2064	59.10652921
200	2	0.966666667	34.8	93	0.2232	64.13793103
220	2.2	0.963333333	34.68	97	0.2328	67.12802768
240	2.4	0.96	34.56	101	0.2424	70.13888889
260	2.6	0.956666667	34.44	105	0.252	73.17073171
280	2.8	0.953333333	34.32	108	0.2592	75.52447552

300	3	0.95	34.2	110	0.264	77.19298246
320	3.2	0.946666667	34.08	112	0.2688	78.87323944
340	3.4	0.943333333	33.96	112	0.2688	79.15194346
360	3.6.	0.94	33.84	113	0.2712	80.14184397
380	3.8	0.936666667	33.72	114	0.2736	81.13879004
400	4	0.933333333	33.6	113	0.2712	80.71428571
420	4.2	0.93	33.48	112	0.2688	80.28673835
440	4.4	0.926666667	33.36	111	0.2664	79.85611511

Table 5.13.DST for soil sample with 100 kPa normal stress



Graph 5.12.stress strain curve

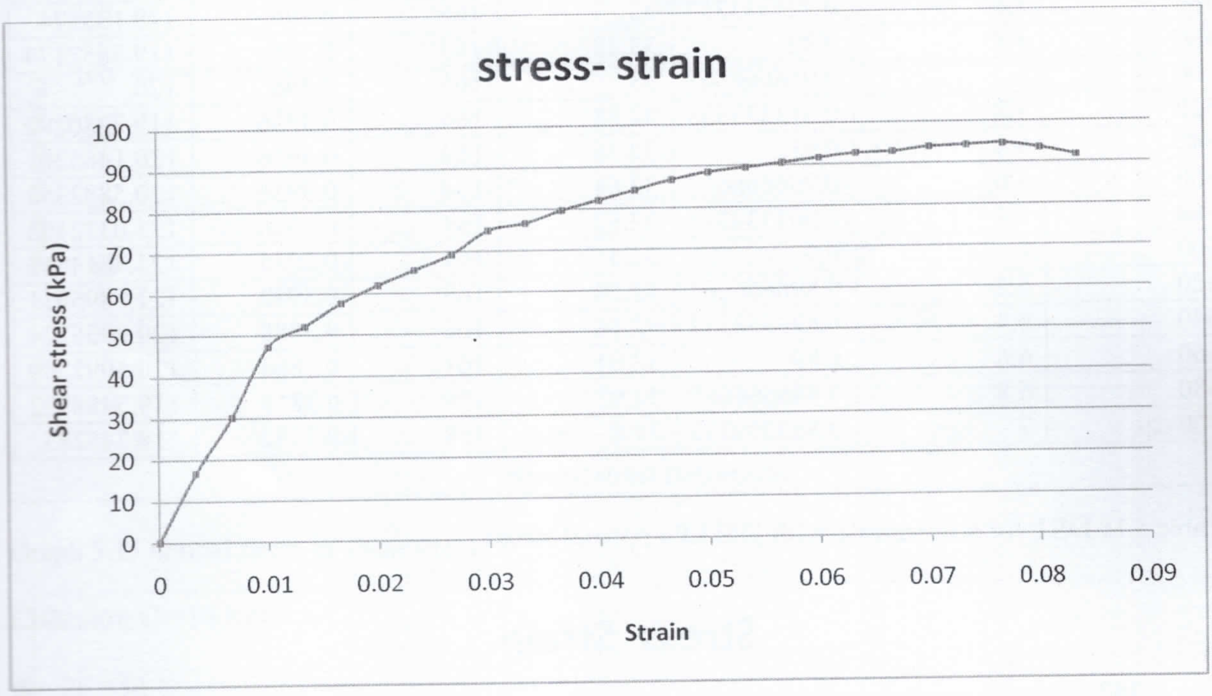
5.7 Direct Shear Test 3

DST for soil sample with 150 kPa normal stress

Displacement dial reading	Displacement (D.D.R*LC) LC=0.01mm	Area correction	Corrected Area(sq.cm)	Stress dial reading	Shear force(kN)	Shear stress(kPa)
0	0	1	36	0	0	0
20	0.2	0.996666667	35.88	25	0.06	16.72240803
40	0.4	0.993333333	35.76	45	0.108	30.20134228
60	0.6	0.99	35.64	70	0.168	47.13804714
80	0.8	0.986666667	35.52	77	0.1848	52.02702703
100	1	0.983333333	35.4	85	0.204	57.62711864
120	1.2	0.98	35.28	91	0.2184	61.9047619
140	1.4	0.976666667	35.16	96	0.2304	65.52901024
160	1.6	0.973333333	35.04	101	0.2424	69.17808219
180	1.8	0.97	34.92	109	0.2616	74.91408935
200	2	0.966666667	34.8	111	0.2664	76.55172414
220	2.2	0.963333333	34.68	115	0.276	79.58477509
240	2.4	0.96	34.56	118	0.2832	81.94444444
260	2.6	0.956666667	34.44	121	0.2904	84.32055749
280	2.8	0.953333333	34.32	124	0.2976	86.71328671

300	3	0.95	34.2	126	0.3024	88.42105263
320	3.2	0.946666667	34.08	127	0.3048	89.43661972
340	3.4	0.943333333	33.96	128	0.3072	90.45936396
360	3.6	0.94	33.84	129	0.3096	91.4893617
380	3.8	0.936666667	33.72	130	0.312	92.52669039
400	4	0.933333333	33.6	130	0.312	92.85714286
420	4.2	0.93	33.48	131	0.3144	93.90681004
440	4.4	0.926666667	33.36	131	0.3144	94.24460432
460	4.6	0.923333333	33.24	131	0.3144	94.58483755
480	4.8	0.92	33.12	129	0.3096	93.47826087
500	5	0.916666667	33	126	0.3024	91.63636364

Table 5.14.DST for soil sample with 150 kPa normal stress



Graph 5.13.stress strain curve

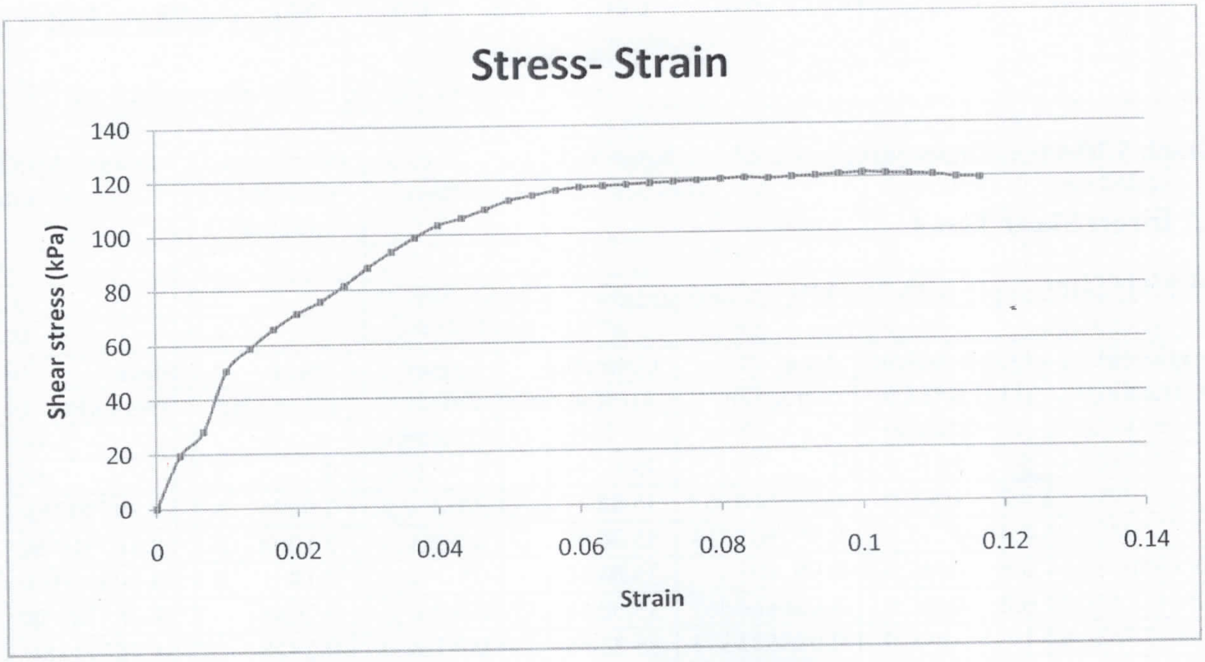
5.7 Direct Shear Test 4

DST for soil sample with 200 kPa normal stress

Displacement dial reading	Displacement (D.D.R*LC) LC=0.01mm	Area correction	Corrected Area(sq.cm)	Stress dial reading	Shear force(kN)	Shear stress(kPa)
0	0	1	36	0	0	0
20	0.2	0.996666667	35.88	29	0.0696	19.39799331
40	0.4	0.993333333	35.76	42	0.1008	28.18791946
60	0.6	0.99	35.64	75	0.18	50.50505051
80	0.8	0.986666667	35.52	87	0.2088	58.78378378
100	1	0.983333333	35.4	97	0.2328	65.76271186
120	1.2	0.98	35.28	105	0.252	71.42857143
140	1.4	0.976666667	35.16	111	0.2664	75.76791809
160	1.6	0.973333333	35.04	119	0.2856	81.50684932

180	1.8	0.97	34.92	128	0.3072	87.97250859
200	2	0.966666667	34.8	136	0.3264	93.79310345
220	2.2	0.963333333	34.68	143	0.3432	98.96193772
240	2.4	0.96	34.56	149	0.3576	103.4722222
260	2.6	0.956666667	34.44	152	0.3648	105.9233449
280	2.8	0.953333333	34.32	156	0.3744	109.0909091
300	3	0.95	34.2	160	0.384	112.2807018
320	3.2	0.946666667	34.08	162	0.3888	114.084507
340	3.4	0.943333333	33.96	164	0.3936	115.9010601
360	3.6	0.94	33.84	165	0.396	117.0212766
380	3.8	0.936666667	33.72	165	0.396	117.4377224
400	4	0.933333333	33.6	165	0.396	117.8571429
420	4.2	0.93	33.48	165	0.396	118.2795699
440	4.4	0.926666667	33.36	165	0.396	118.705036
460	4.6	0.923333333	33.24	165	0.396	119.133574
480	4.8	0.92	33.12	165	0.396	119.5652174
500	5	0.916666667	33	165	0.396	120
520	5.2	0.913333333	32.88	164	0.3936	119.7080292
540	5.4	0.91	32.76	164	0.3936	120.1465201
560	5.6	0.906666667	32.64	164	0.3936	120.5882353
580	5.8	0.903333333	32.52	164	0.3936	121.0332103
600	6	0.9	32.4	164	0.3936	121.4814815
620	6.2	0.896666667	32.28	163	0.3912	121.1895911
640	6.4	0.893333333	32.16	162	0.3888	120.8955224
660	6.6	0.89	32.04	161	0.3864	120.5992509
680	6.8	0.886666667	31.92	159	0.3816	119.5488722
700	7	0.883333333	31.8	158	0.3792	119.245283

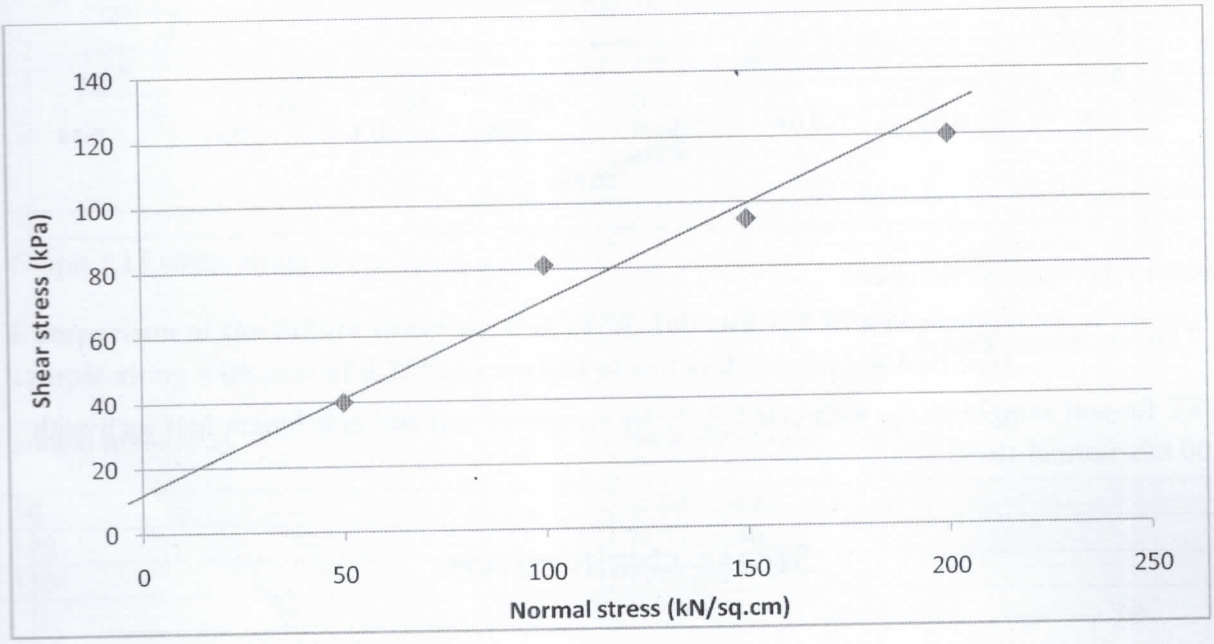
Table 5.15.DST for soil sample with 200 kPa normal stress



Graph 5.14.stress strain curve

Comparison of the failure shear stresses of 50, 100, 150 and 200 kPa normal stress of the soil sample only.

normal stress(kPa)	shear stress(kPa)
50	39.860139860
100	81.13879004
150	94.58483755
200	120



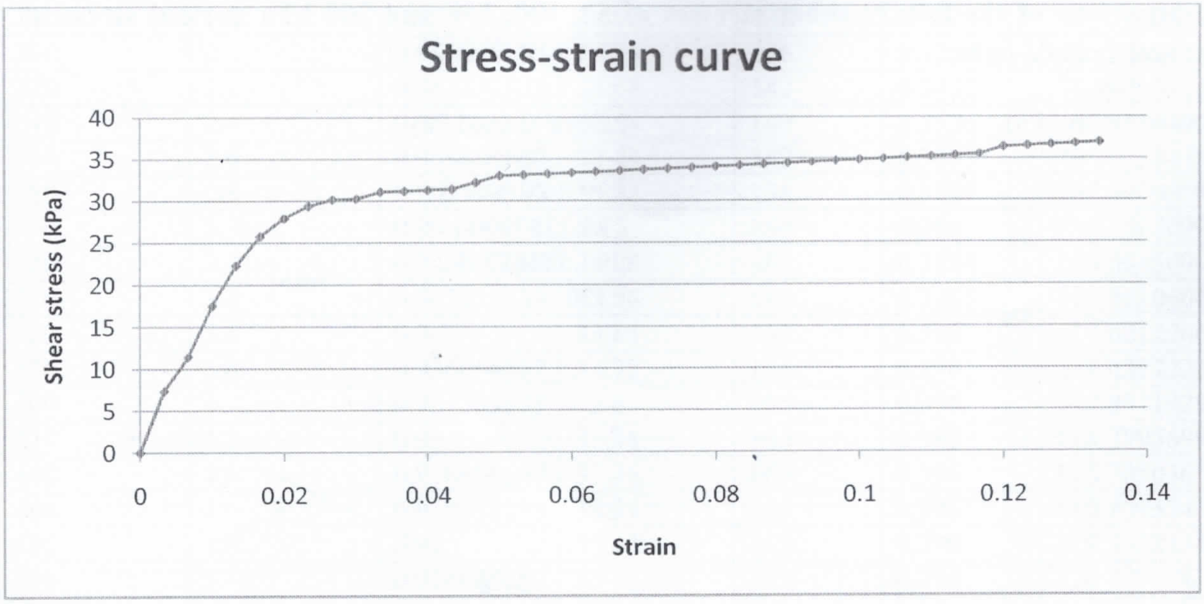
Graph 5.15.normal stress vs shear stress

Cohesion C =10 kPa

Φ= 26 °54 ‘

5.7 Direct Shear Test 5

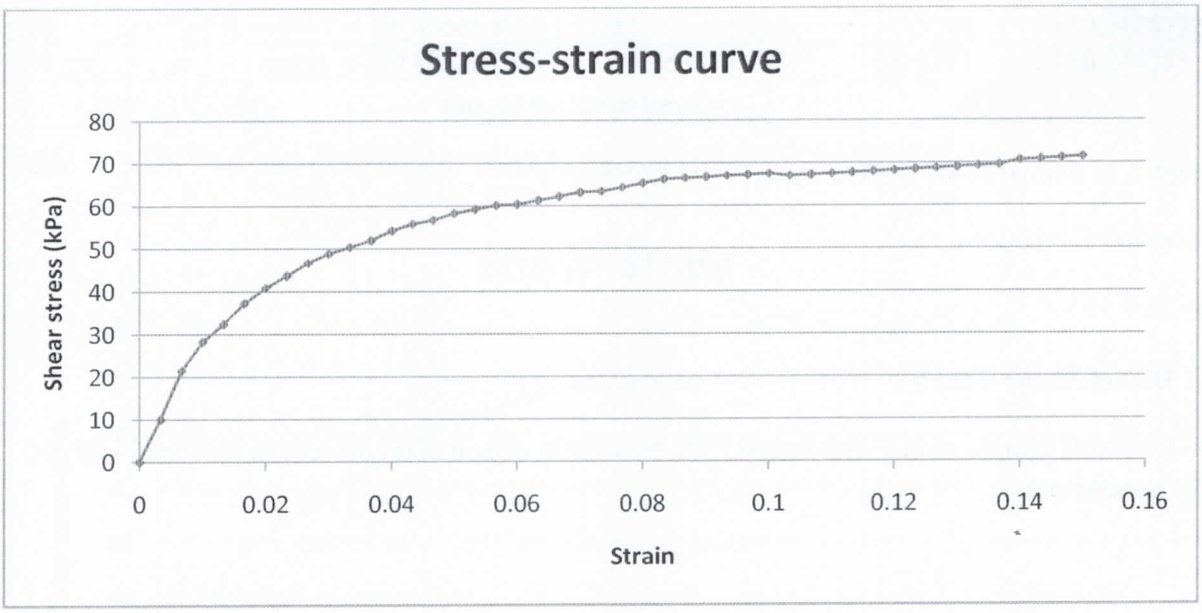
DST for soil sample along with coir 0.25% by weight of soil and coir length half inch with 50 kPa normal stress



Graph 5.16.stress strain curve

5.7 Direct Shear Test 6

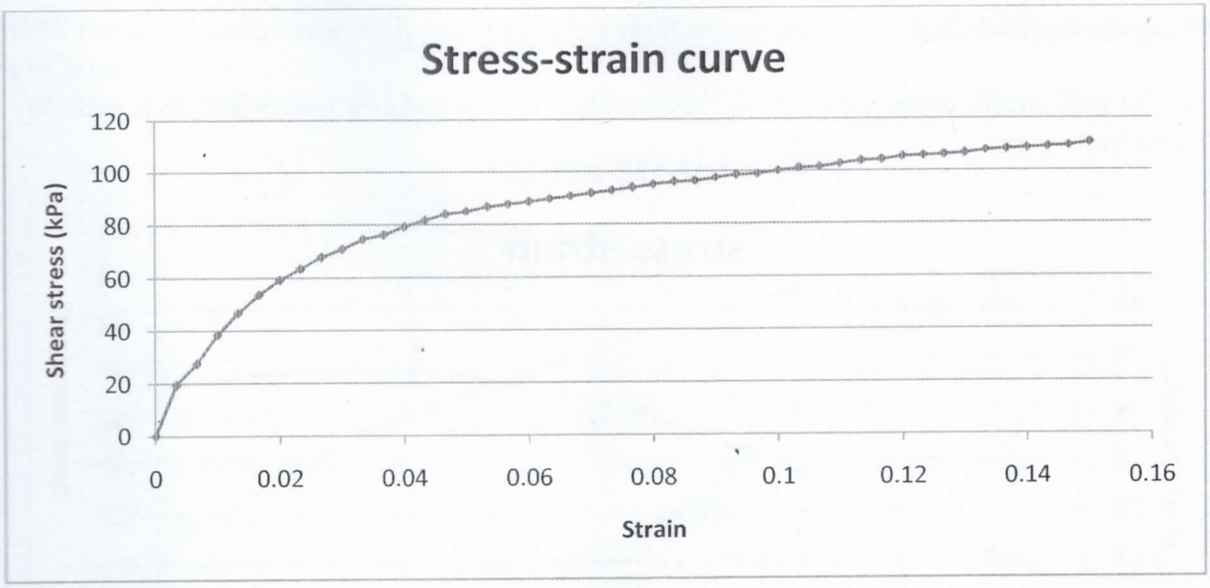
DST for soil sample along with coir 0.25% by weight of soil and coir length half inch with 100 kPa normal stress



Graph 5.17.stress strain curve

5.7 Direct Shear Test 7

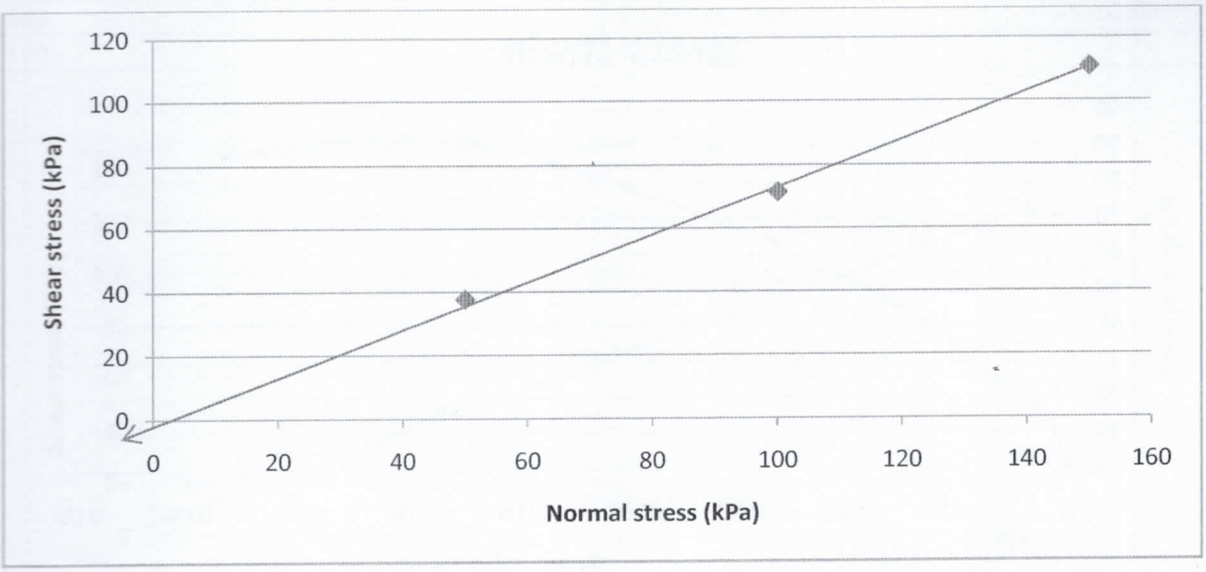
DST for soil sample along with coir 0.25% by weight of soil and coir length half inch with 150 kPa normal stress



Graph 5.18.stress strain curve

Comparison of the failure shear stresses of 50, 100 and 150 kPa normal stress of the soil sample along with coir of 0.25% by weight of soil and coir length half inch.

normal stress(kPa)	shear stress(kPa)
50	37.64705882
100	71.37254902
150	110.5882353



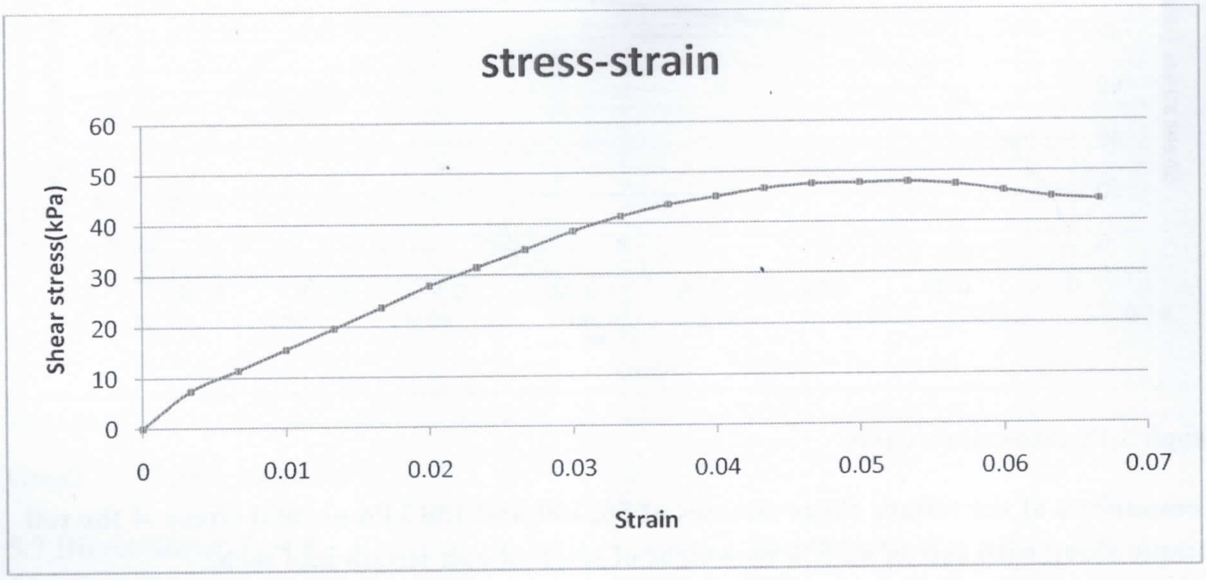
Graph 5.19.normal stress vs shear stress

cohesion =1 kPa

ϕ= 36 ˚6 '

5.7 Direct Shear Test 8

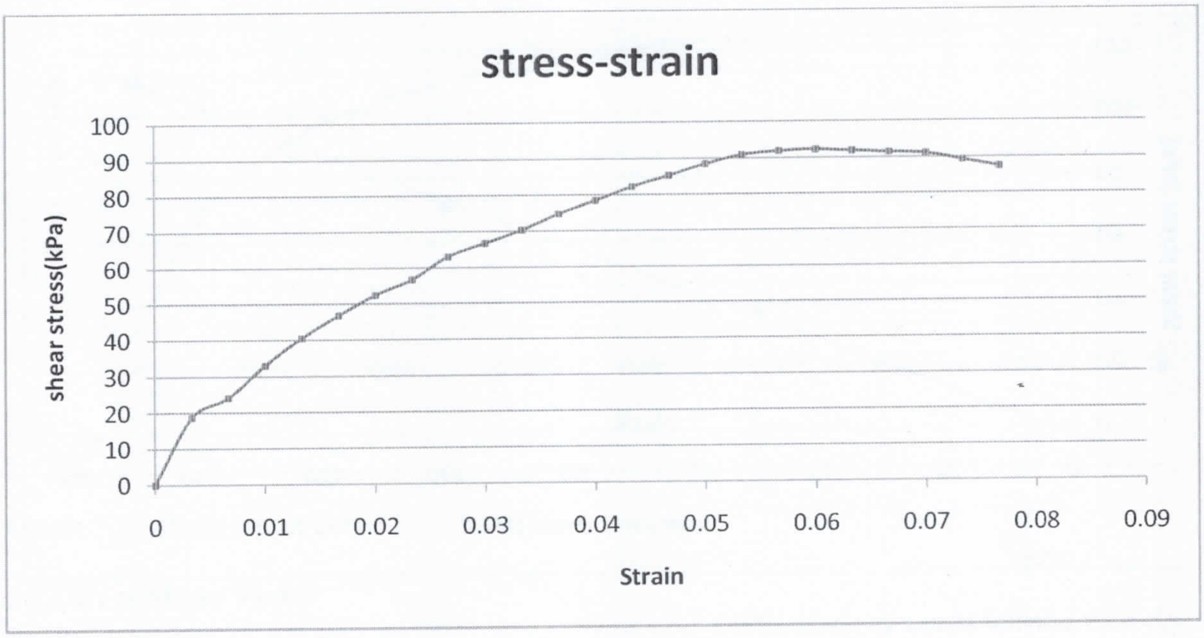
DST for soil sample along with coir 0.5% by weight of soil and coir length half inch with 50 kPa normal stress.



Graph 5.20.stress strain curve

5.7 Direct Shear Test 9

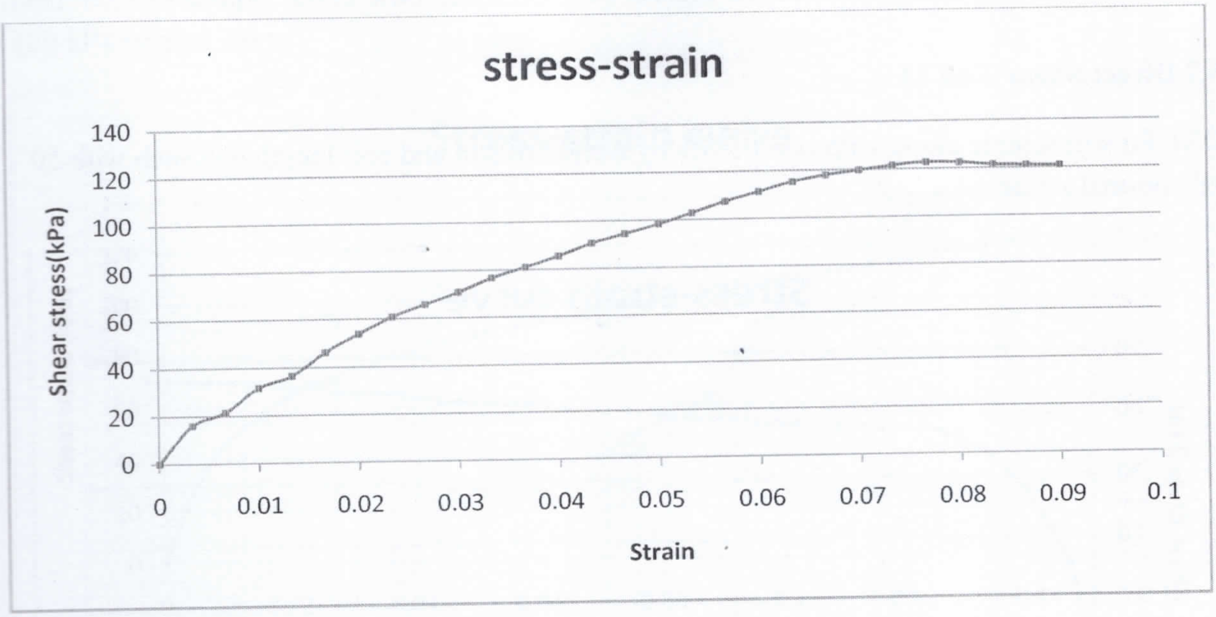
DST for soil sample along with coir 0.5% by weight of soil and coir length half inch with 100 kPanormal stress



Graph 5.21.stress strain curve

5.7 Direct Shear Test 10

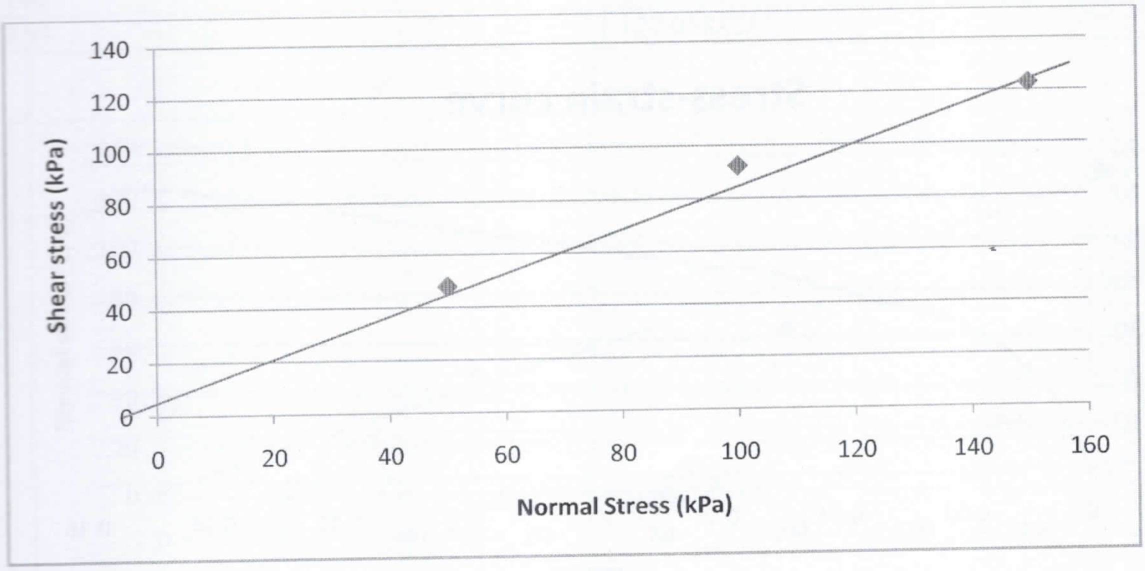
DST for soil sample along with coir 0.5% by weight of soil and coir length half inch with 150 kPa normal stress



Graph 5.22.stress strain curve

Comparison of the failure shear stresses of 50, 100 and 150 kPa normal stress of the soil sample along with coir of 0.5% by weight of soil and coir length half inch.

normal stress(kPa)	shear stress(kPa)
50	47.887323943662
100	92.1985815602837
150	122.743682310469



Graph 5.23.normal stress vs shear stress

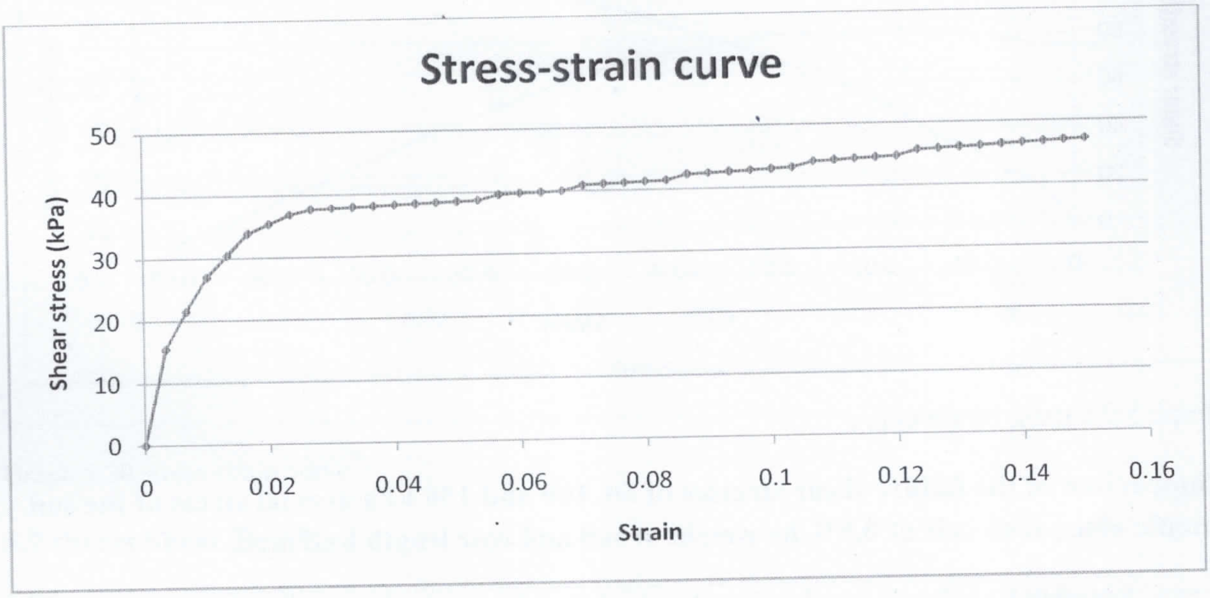
cohesion = 13

kPa

ϕ = 36 °48 '

5.7 Direct Shear Test 11

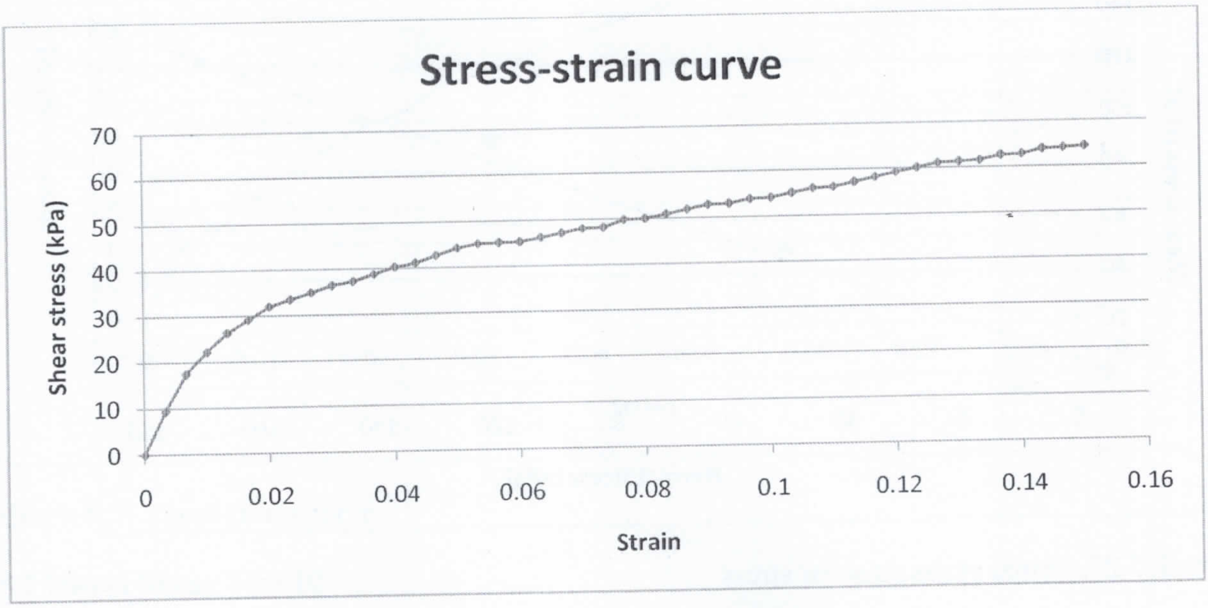
DST for soil sample along with coir 0.75% by weight of soil and coir length half inch with 50 kPa normal stress



Graph 5.24.stress strain curve

5.7 Direct Shear Test 12

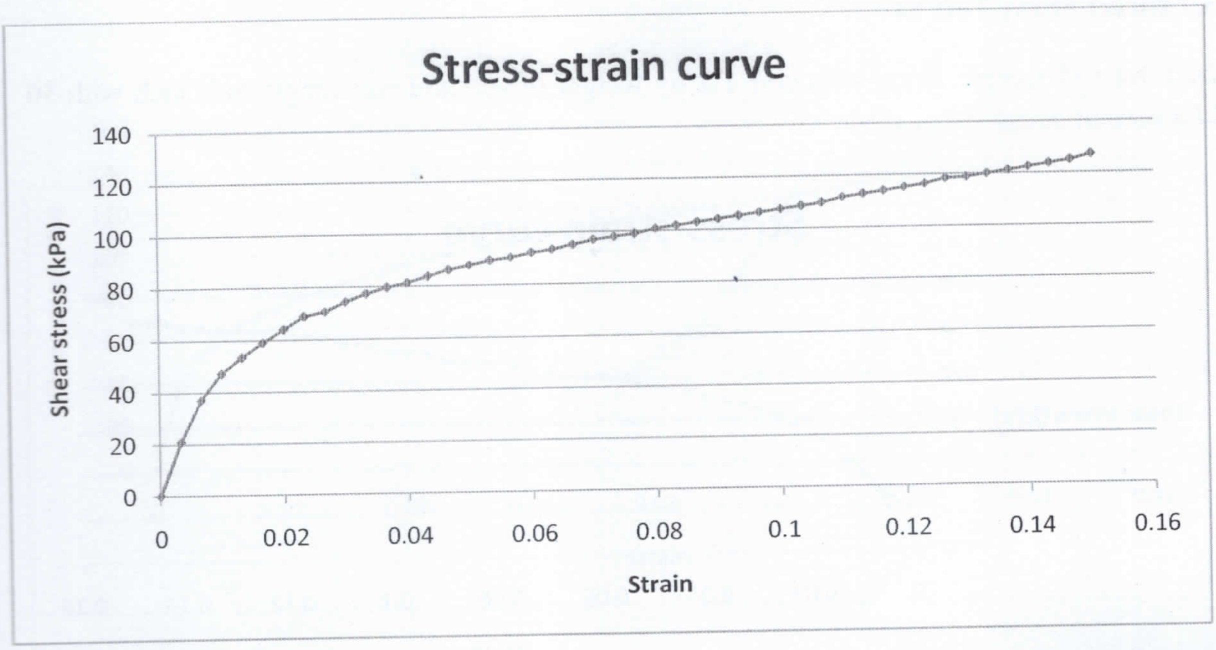
DST for soil sample along with coir 0.75% by weight of soil and coir length half inch with 100 kPa normal stress



Graph 5.25.stres strain curve

5.7 Direct Shear Test 13

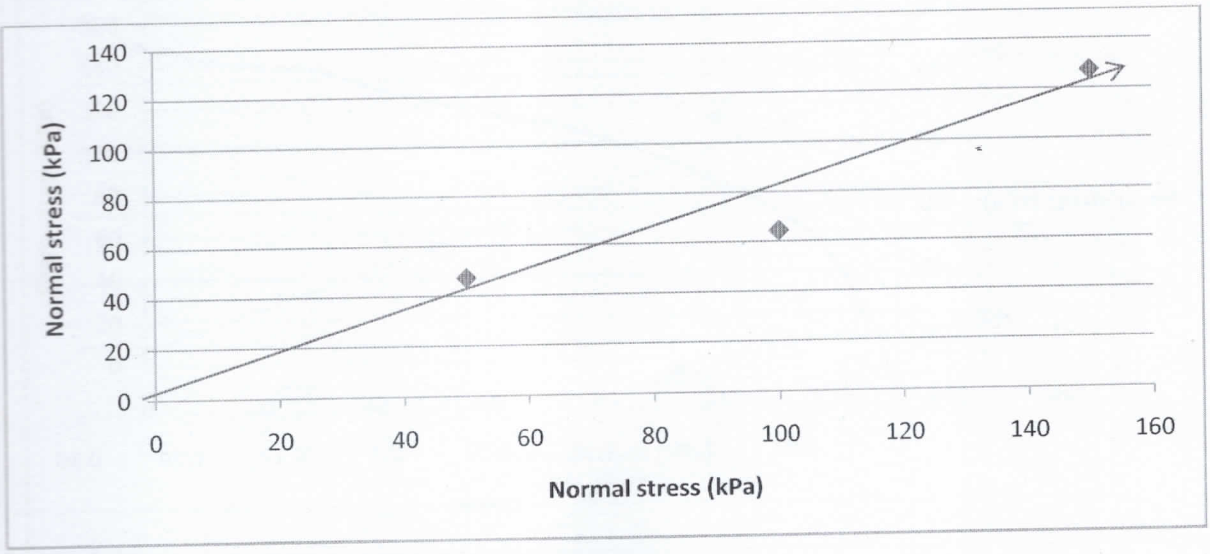
DST for soil sample along with coir 0.75% by weight of soil and coir length half inch with 150 kPa normal stress



Graph 5.26.stress strain curve

Comparison of the failure shear stresses of 50, 100 and 150 kPa normal stress of the soil sample along with coir of 0.75% by weight of soil and coir length half inch.

normal stress(kPa)	shear stress(kPa)
50	47.05882353
100	64.31372549
150	127.0588235

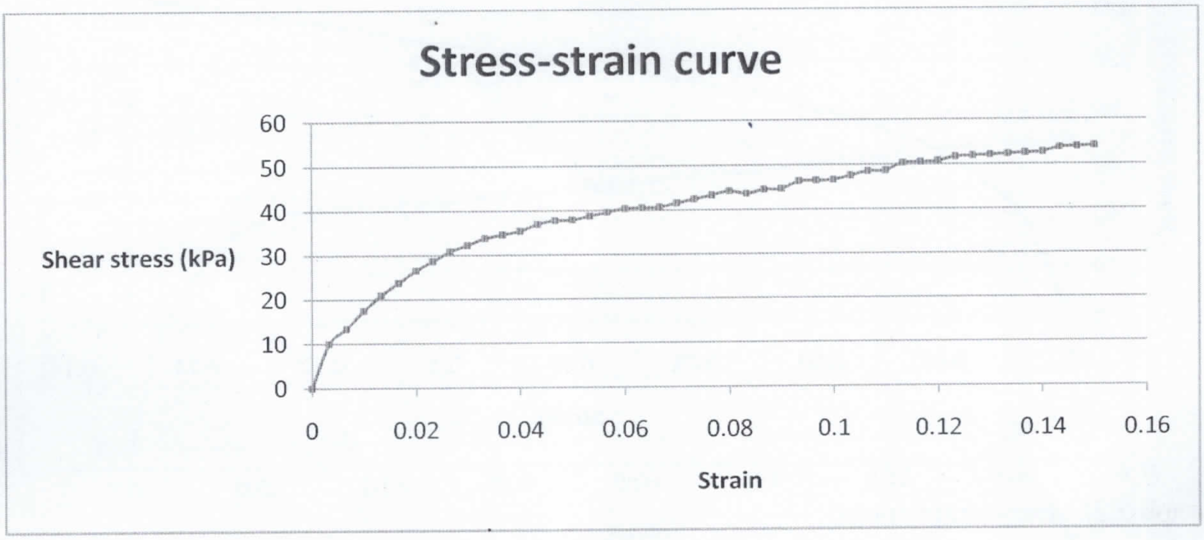


Graph 5.27.normal stress vs shear stress

cohesion = 10 kPa
$\phi = 38^\circ 39'$

5.7 Direct Shear Test 14

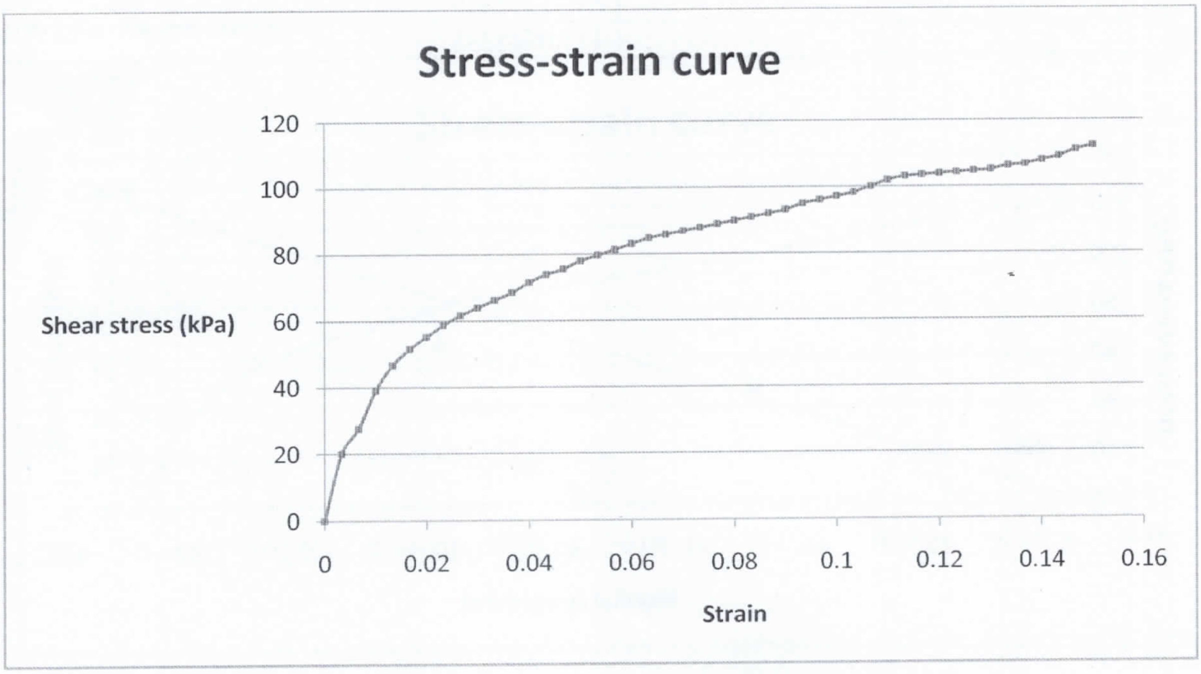
DST for soil sample along with coir 1% by weight of soil and coir length half inch with 50 kPa normal stress



Graph 5.28.stress strain curve

5.7 Direct Shear Test 15

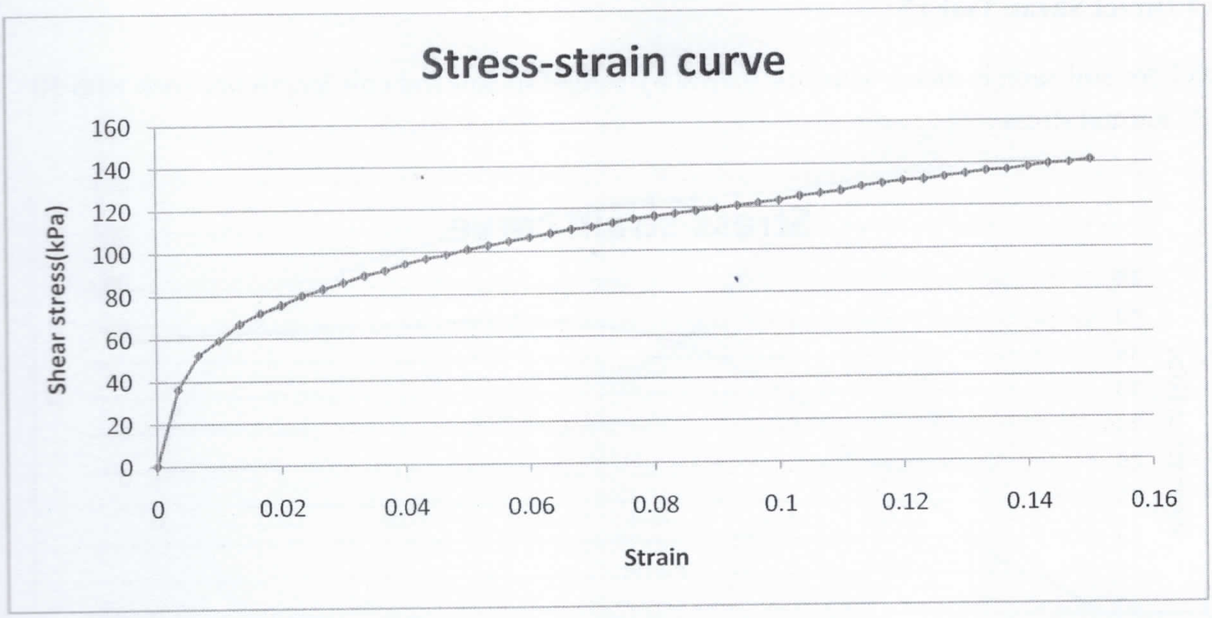
DST for soil sample along with coir 1% by weight of soil and coir length half inch with 100 kPanormal stress



Graph 5.29.stress strain curve

5.7 Direct Shear Test 16

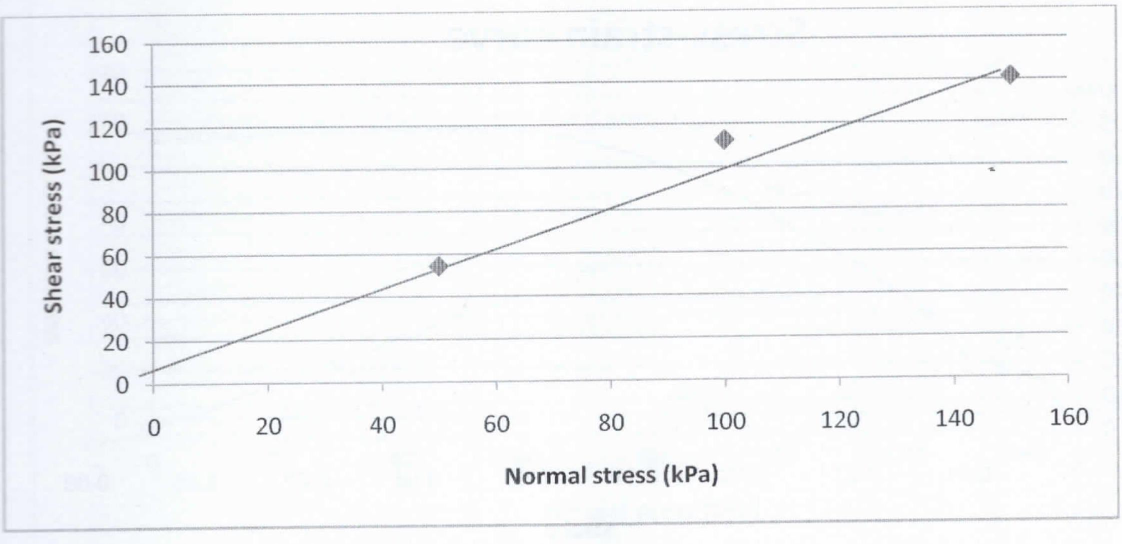
DST for soil sample along with coir 1% by weight of soil and coir length half inch with 150 kPanormal stress.



Graph 5.30.stress strain curve

Comparison of the failure shear stresses of 50, 100 and 150 kPa normal stress of the soil sample along with coir of 1% by weight of soil and coir length half inch.

normal stress(kPa)	shear stress(kPa)
50	54.11764706
100	112.1568627
150	141.1764706



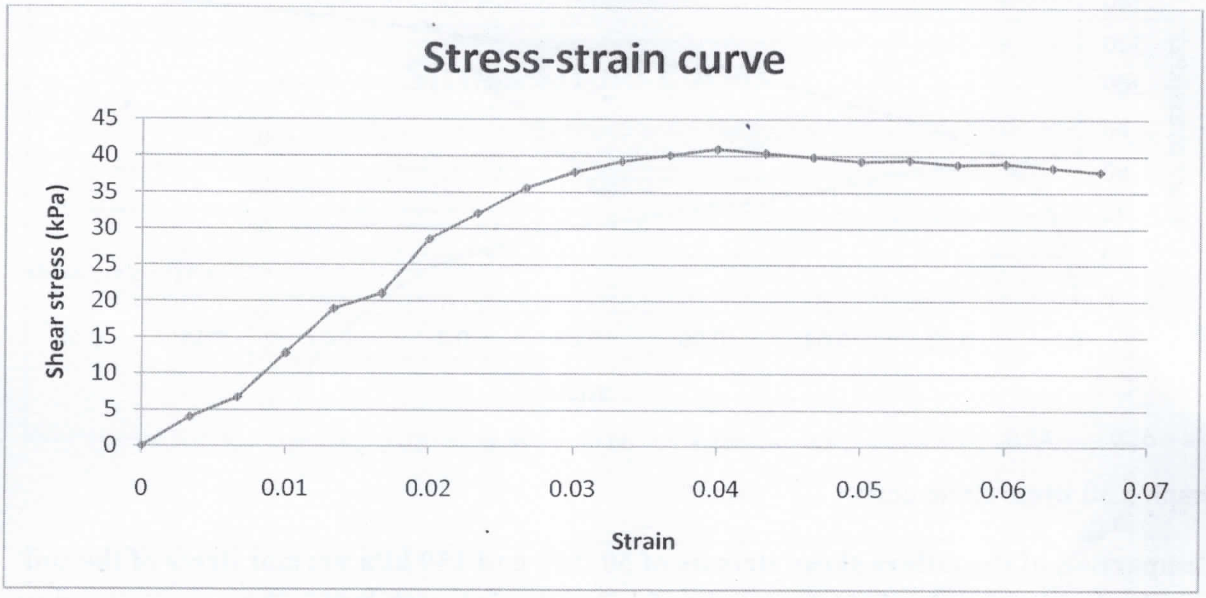
Graph 5.31.normal stress vs shear stress

Cohesion c= 15 kPa

Φ= 41°2′

5.7 Direct Shear Test 17

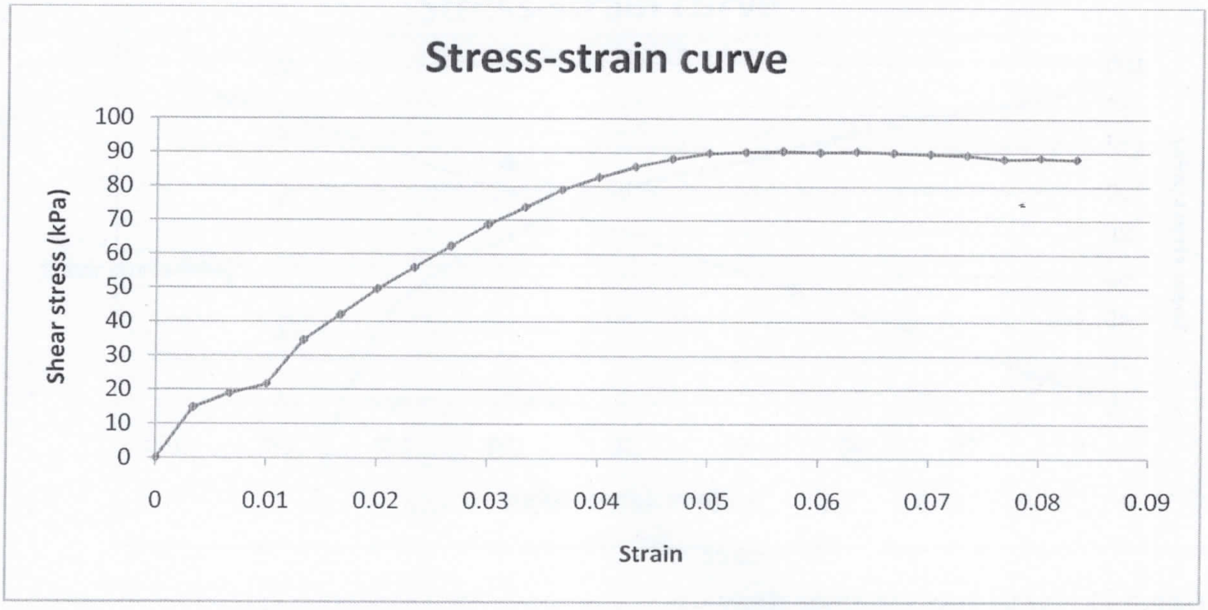
DST for soil sample along with coir 0.25% by weight of soil and coir length one inch with 50 kPa normal stress



Graph 5.32.stress strain curve

5.7 Direct Shear Test 18

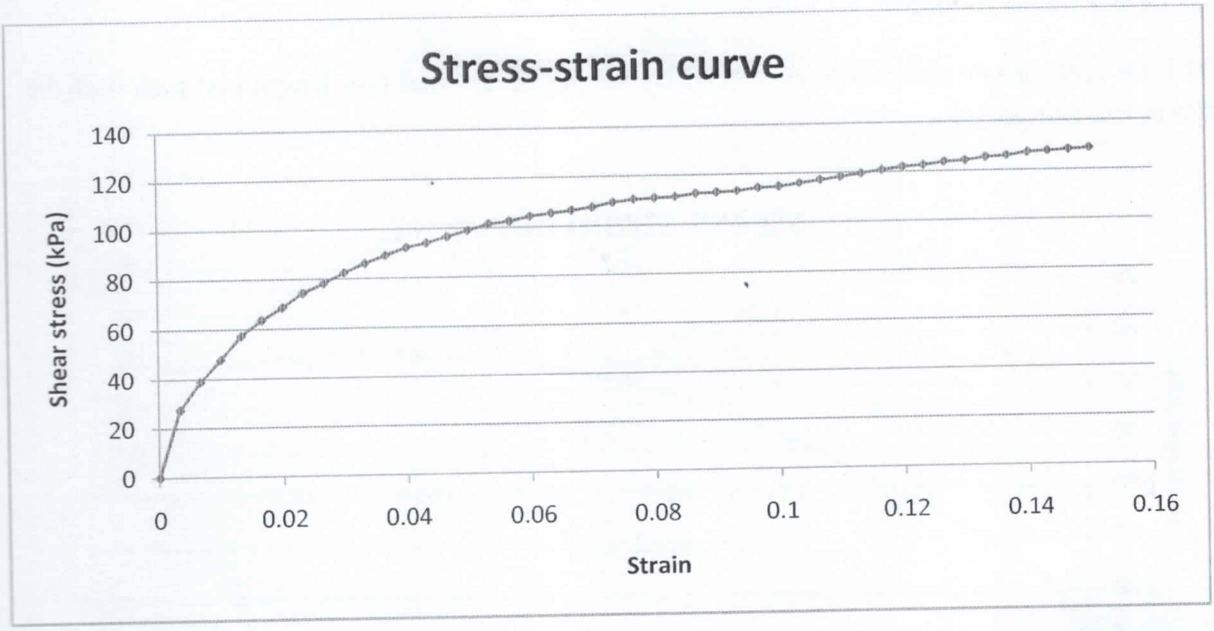
DST for soil sample along with coir 0.25% by weight of soil and coir length one inch with 100 kPa normal stress



Graph 5.33.stress strain curve

5.7 Direct Shear Test 19

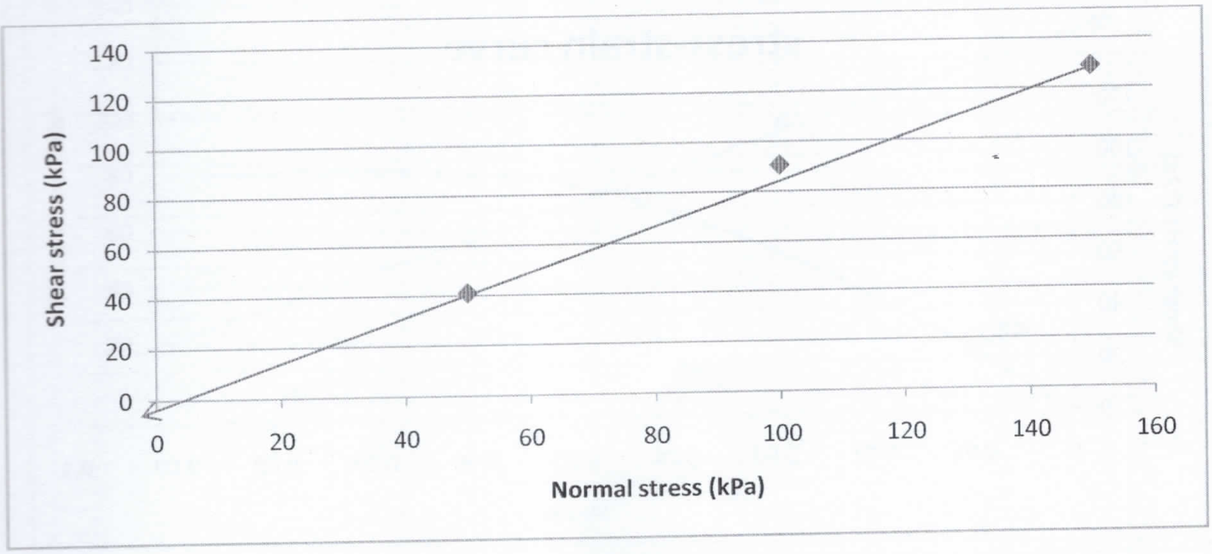
DST for soil sample along with coir 0.25% by weight of soil and coir length one inch with 150 kPa normal stress



Graph 5.34.stress strain curve

Comparison of the failure shear stresses of 50, 100 and 150 kPa normal stress of the soil sample along with coir of 0.25% by weight of soil and coir length one inch.

normal stress(kPa)	shear stress(kPa)
50	40.97222222
100	90.45936396
150	128.627451

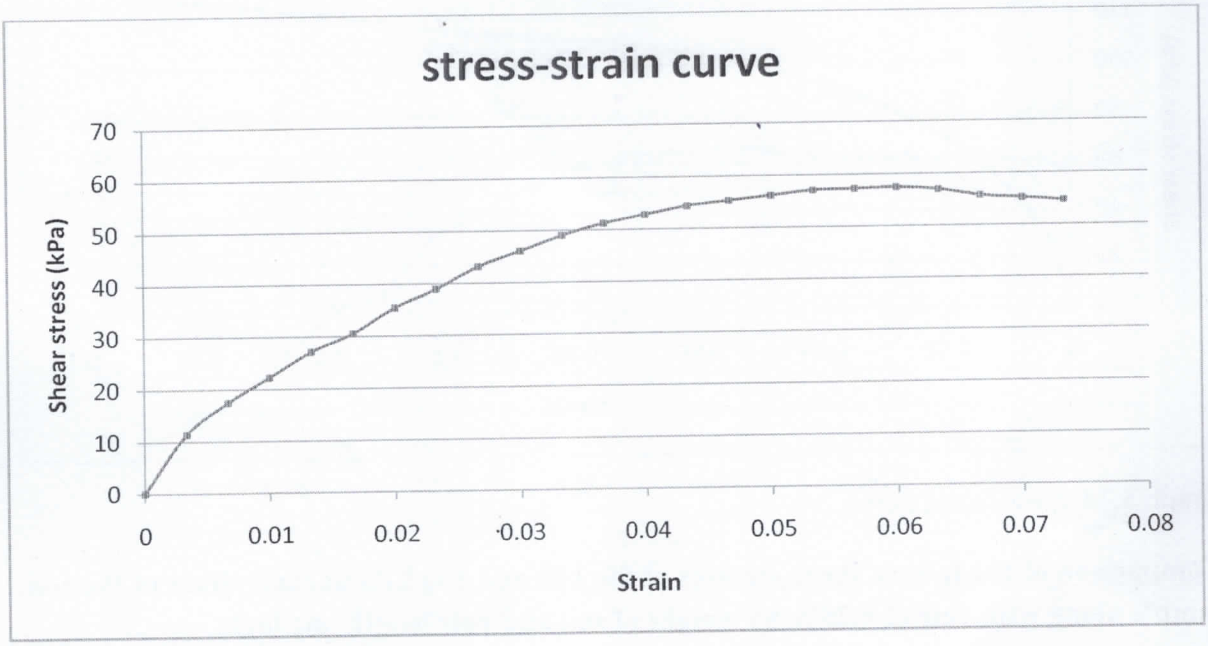


Graph 5.35.normal stress vs shear stress

Cohesion = 2 kPa
ϕ= 41 °13 '

5.7 Direct Shear Test 20

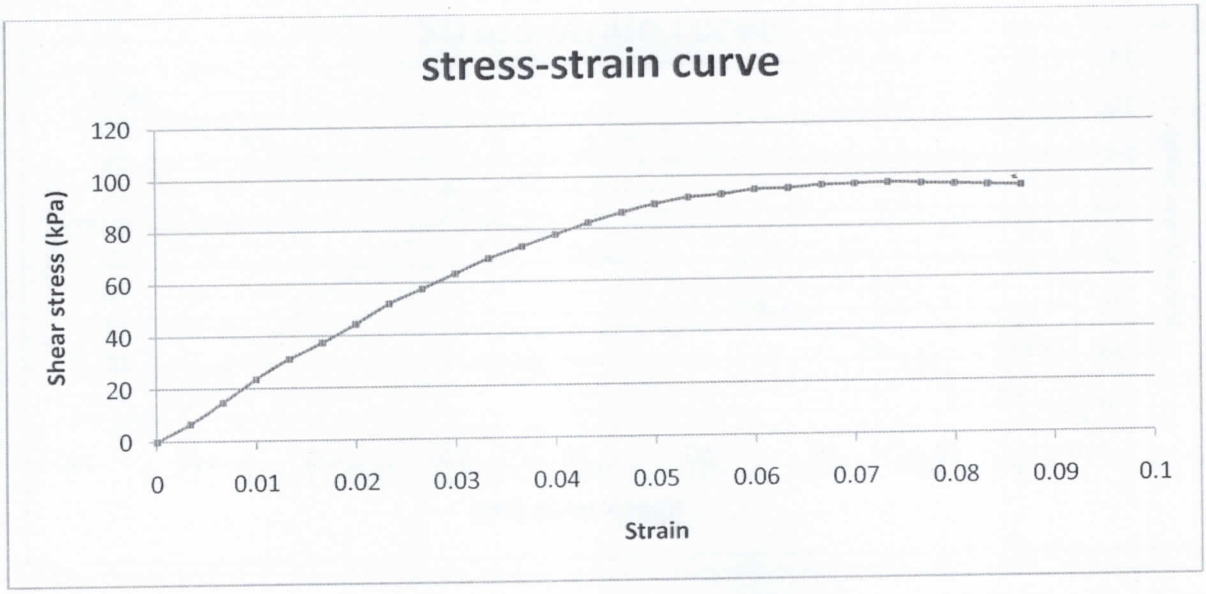
DST for soil sample along with coir 0.5% by weight of soil and coir length one inch with 50 kPa normal stress



Graph 5.36.stress strain curve

5.7 Direct Shear Test 21

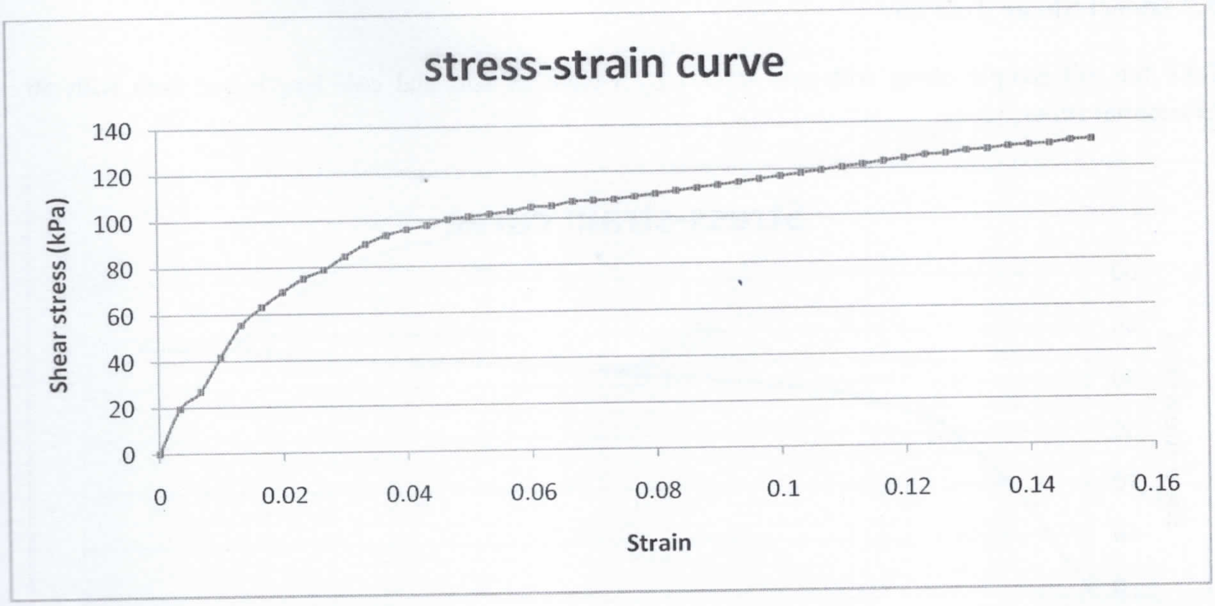
DST for soil sample along with coir 0.5% by weight of soil and coir length one inch with 100 kPanormal stress



Graph 5.37.stress strain curve

5.7 Direct Shear Test 22

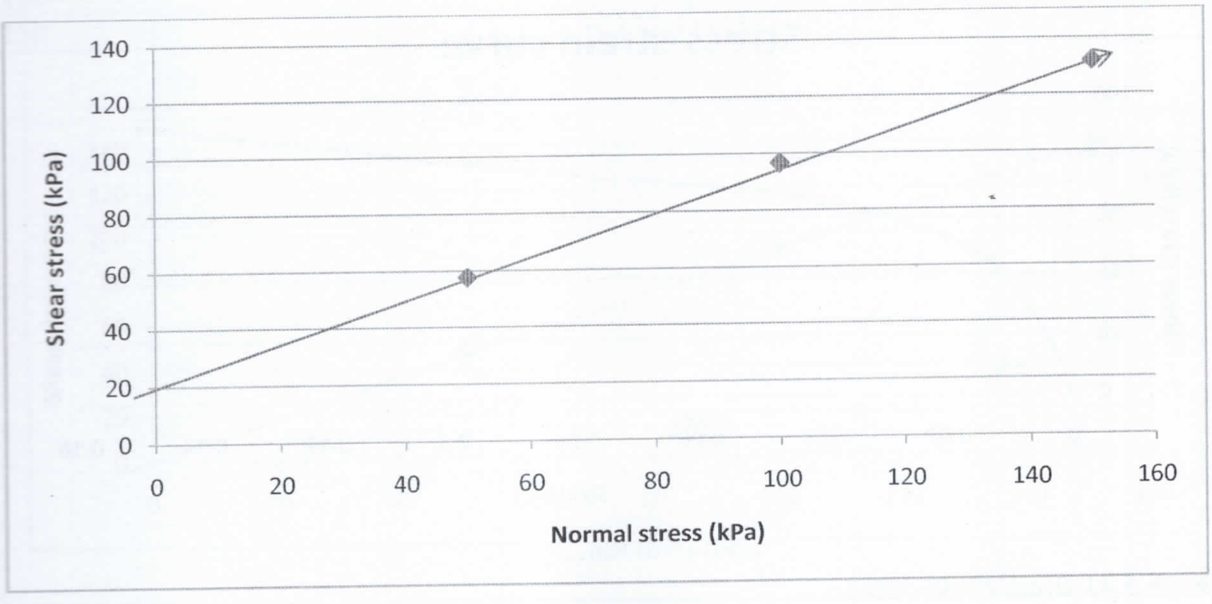
DST for soil sample along with coir 0.5% by weight of soil and coir length one inch with 150 kPanormal stress.



Graph 5.38.stress strain curve

Comparison of the failure shear stresses of 50, 100 and 150 kPa normal stress of the soil sample along with coir of 0.5% by weight of soil and coir length one inch.

normal stress(kPa)	shear stress(kPa)
50	57.44680851
100	96.4028777
150	131.7647059



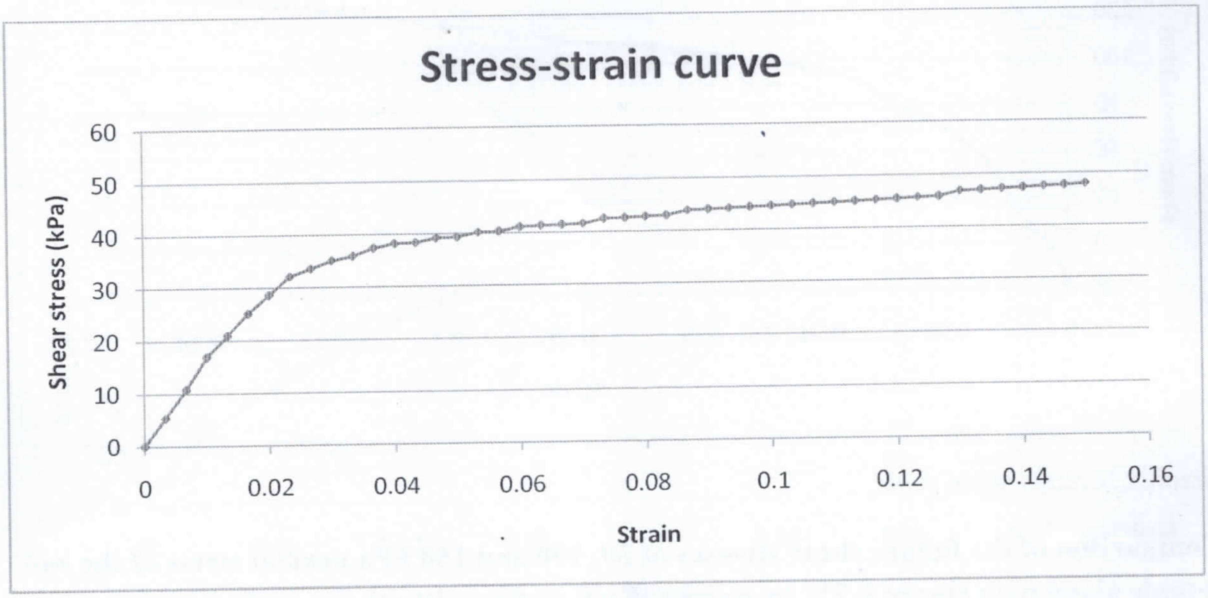
Graph 5.39.normal stress vs shear stress

cohesion = 21 kPa

ϕ= 36 °37 '

5.7 Direct Shear Test 23

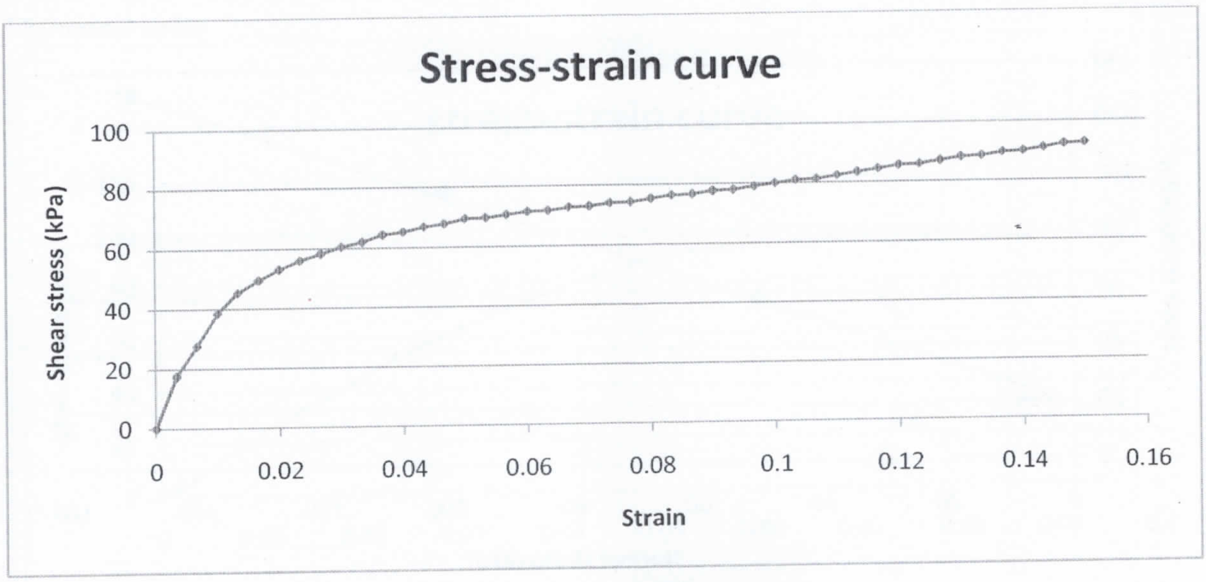
DST for soil sample along with coir 0.75% by weight of soil and coir length one inch with 50 kPanormal stress



Graph 5.40.stress strain curve

5.7 Direct Shear Test 24

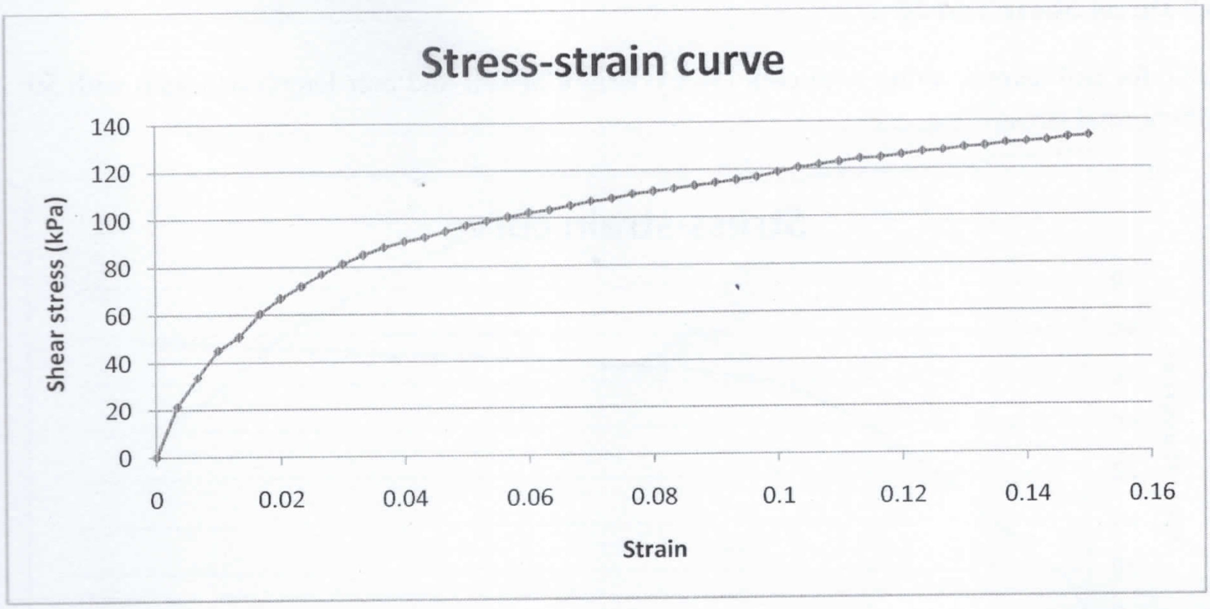
DST for soil sample along with coir 0.75% by weight of soil and coir length one inch with 100 kPa normal stress



Graph 5.41.stress strain curve

5.7 Direct Shear Test 25

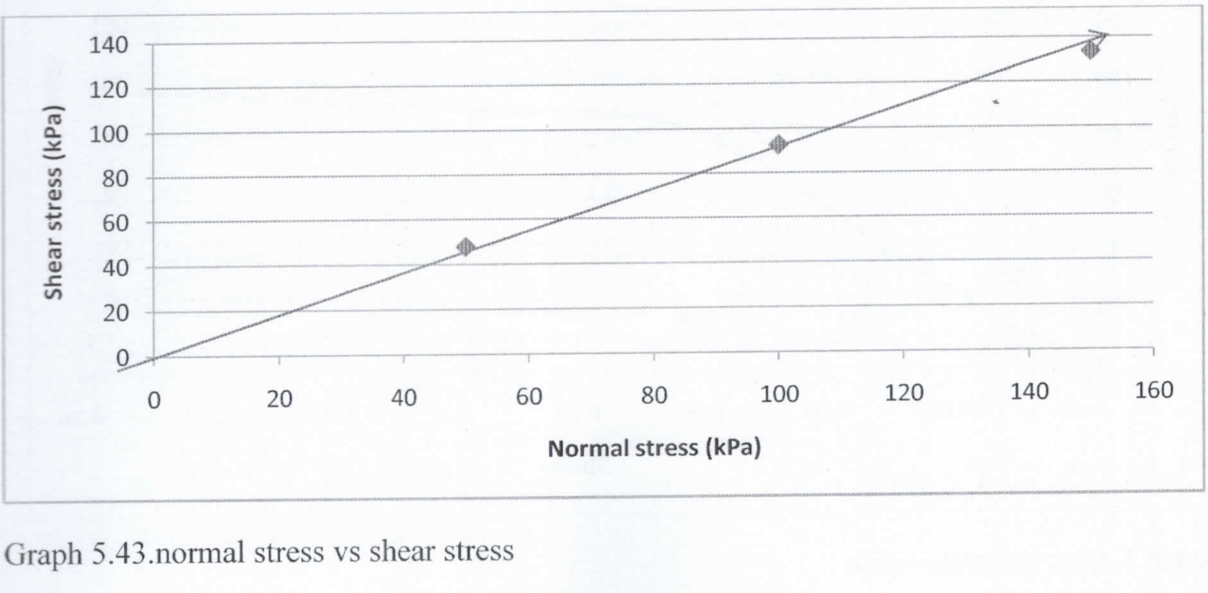
DST for soil sample along with coir 0.75% by weight of soil and coir length one inch with 150 kPanormal stress



Graph 5.42.stress strain curve

Comparison of the failure shear stresses of 50, 100 and 150 kPa normal stress of the soil sample along with coir of 0.75% by weight of soil and coir length one inch.

normal stress (kPa)	shear stress (kPa)
50	47.84313725
100	92.54901961
150	133.3333333

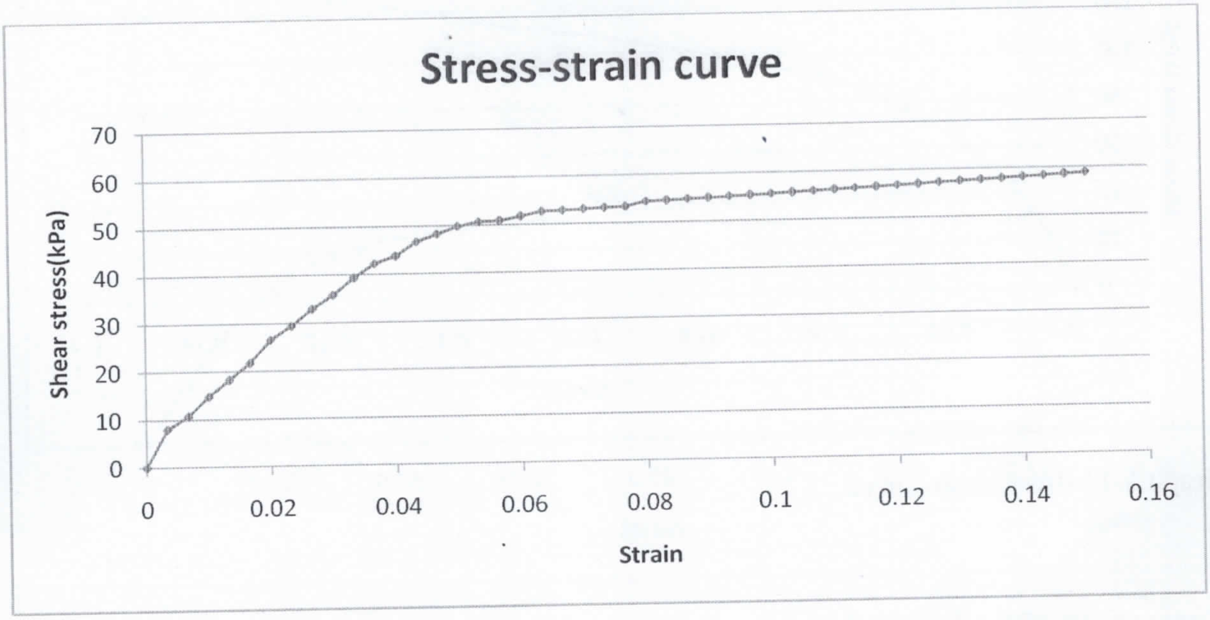


Graph 5.43.normal stress vs shear stress

Cohesion = 6 kPa
ϕ= 40 °31 '

5.7 Direct Shear Test 26

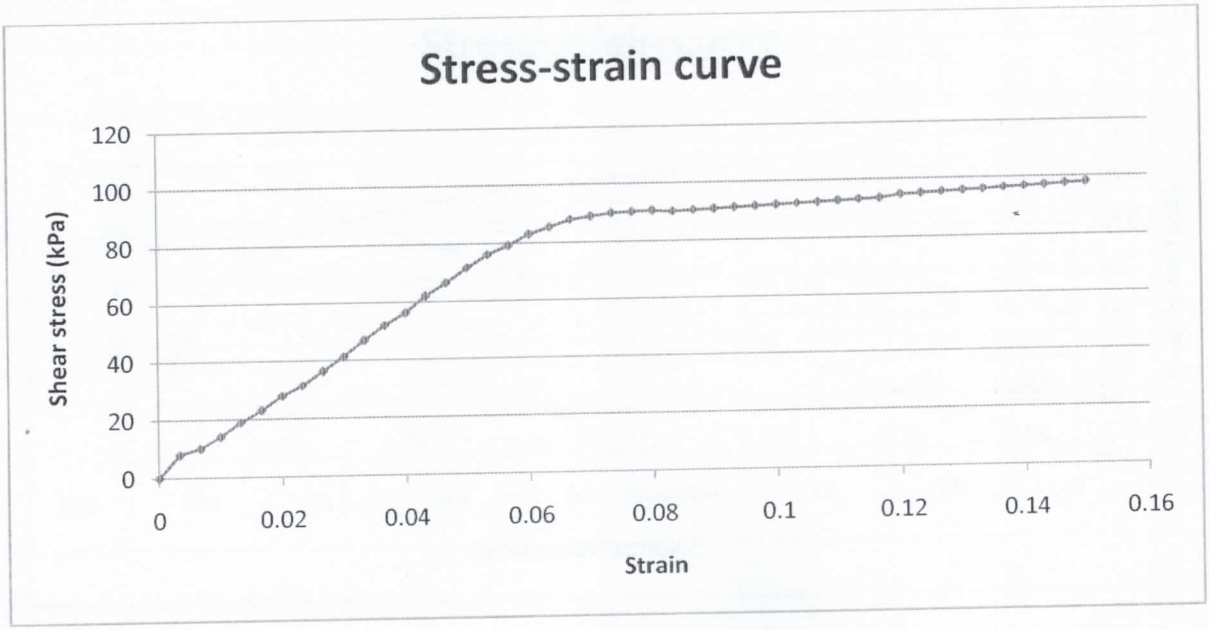
DST for soil sample along with coir 1% by weight of soil and coir length one inch with 50 kPa normal stress



Graph 5.44.stress strain curve

5.7 Direct Shear Test 27

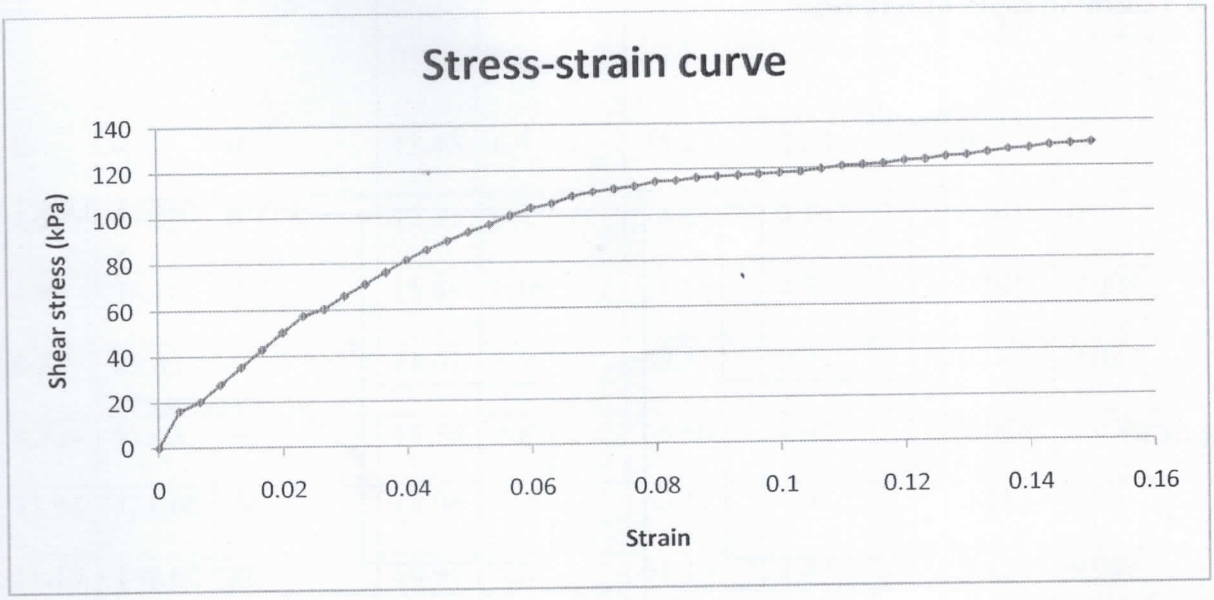
DST for soil sample along with coir 1% by weight of soil and coir length one inch with 100 kPa normal stress



Graph 5.45.stress strain curve

5.7 Direct Shear Test 28

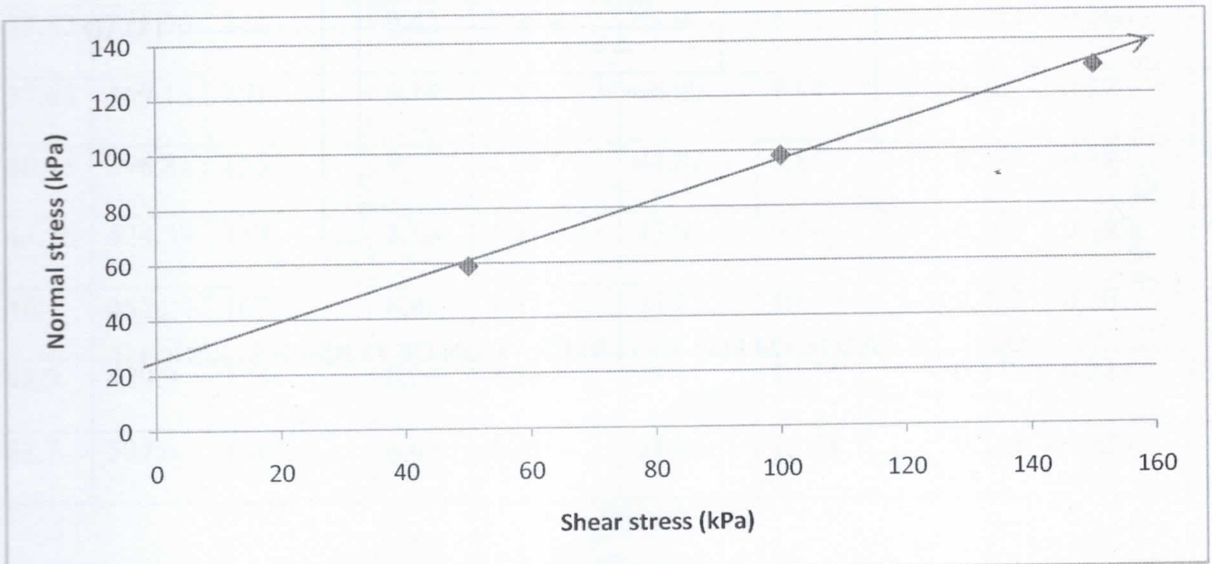
DST for soil sample along with coir 1% by weight of soil and coir length one inch with 150 kPa normal stress



Graph 5.46.stress strain curve

Comparison of the failure shear stresses of 50, 100 and 150 kPa normal stress of the soil sample along with coir of 1% by weight of soil and coir length one inch.

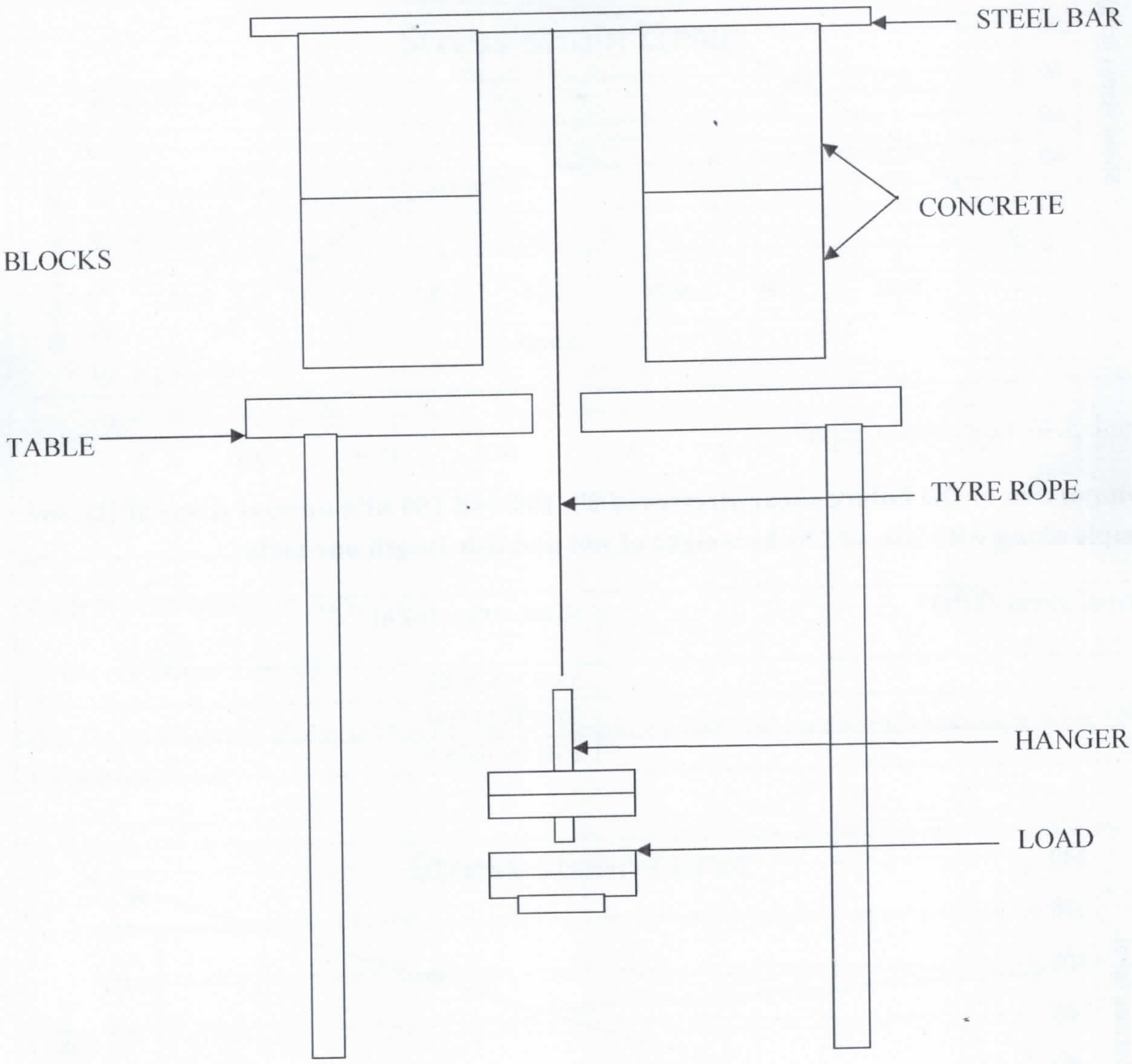
normal stress (kPa)	shear stress (kPa)
50	58.82352941
100	98.03921569
150	130.1960784



Graph 5.47.normal stress vs shear stress

cohesion = 24 kPa
ϕ= 35 °30 '

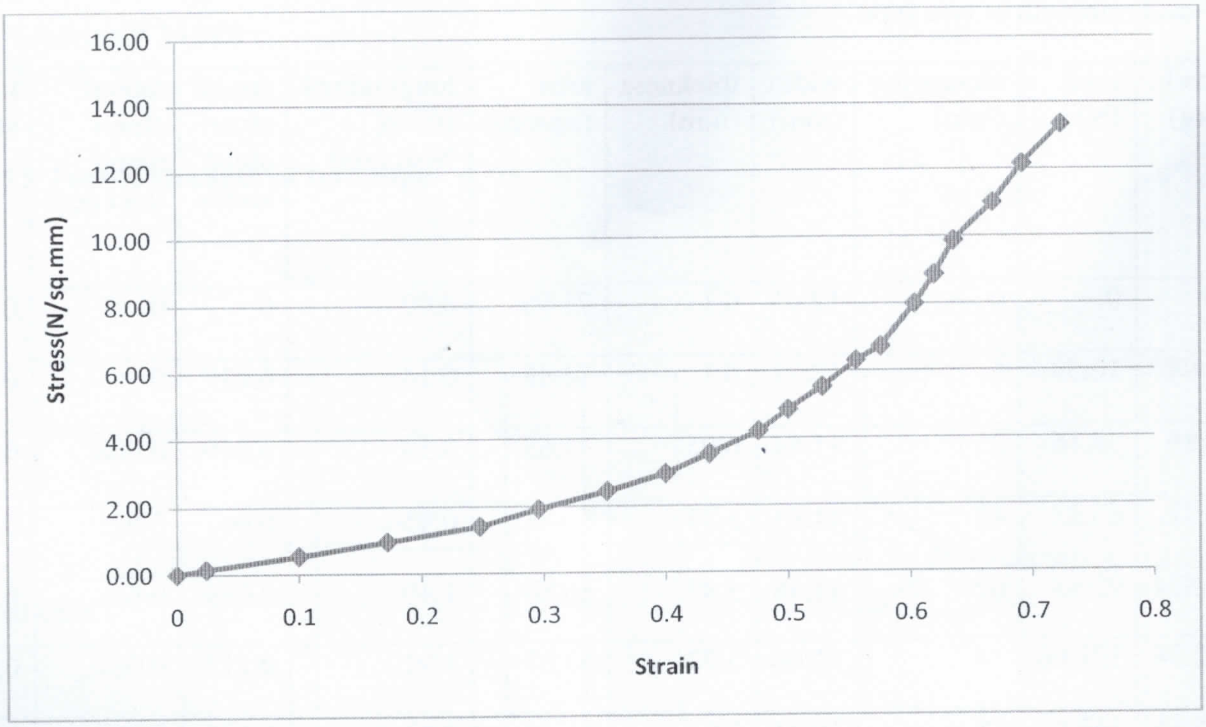
5.8 Tensile strength of tyre rope



5. DIAGRAM FOR DETERMINATION OF TENSILE STRENGTH

Tensile strength of tyre rope

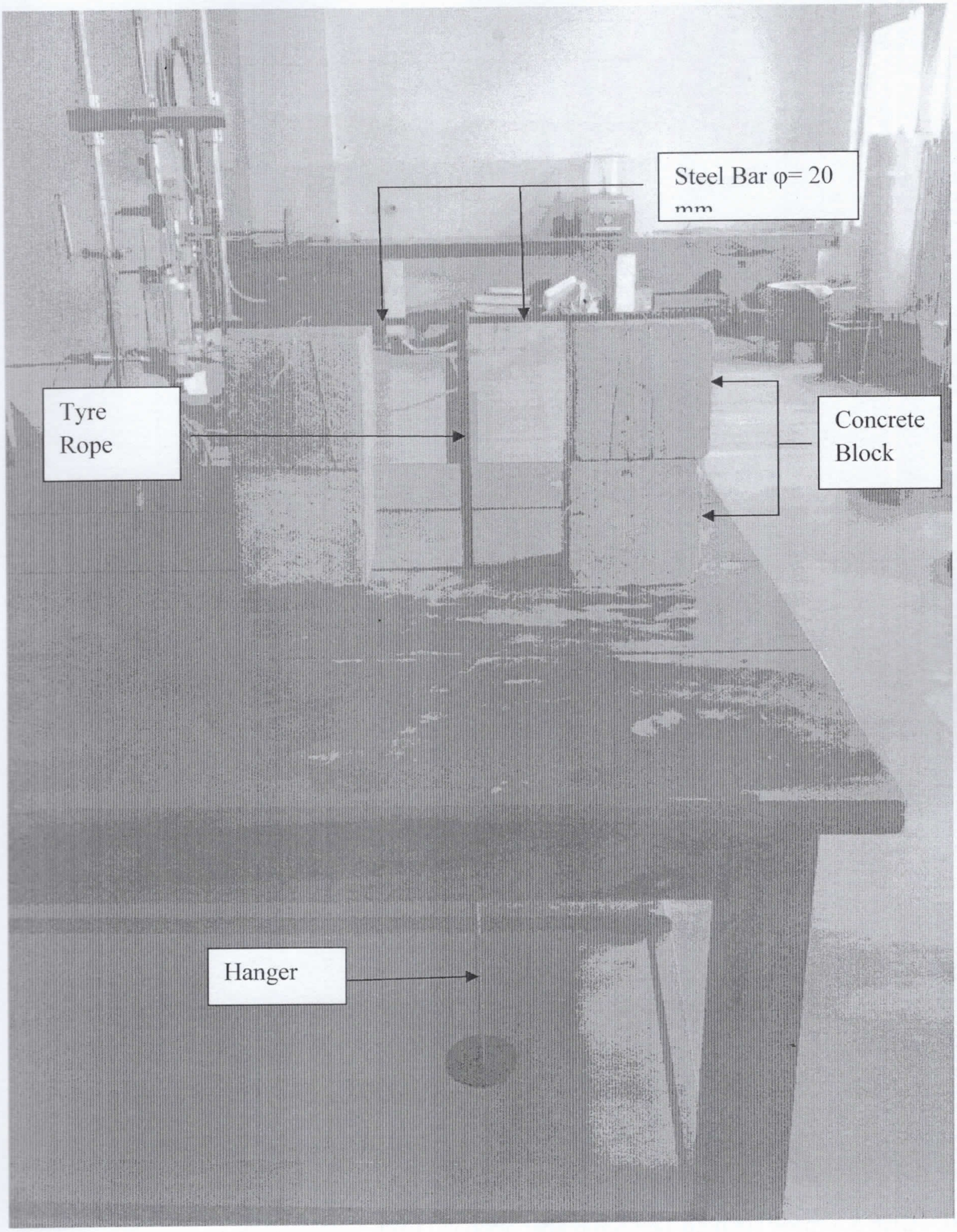
load (kg)	load (N)	elongation (mm)	width (mm)	thickness (mm)	area (sq.mm)	longitudinal stress(N/sq.mm)	lateral strain along width	lateral strain along thickness	longitudinal strain
0	0	0	12.45	6.1	75.95	0.00	0	0	0
1.08	10.59	6	12.21	6.1	74.48	0.14	0.019	0	0.024
3.89	38.16	25	11.84	6.05	71.63	0.53	0.049	0.008	0.1
6.71	65.83	43	11.61	5.97	69.31	0.95	0.067	0.021	0.172
9.524	93.43	62	11.38	5.87	66.80	1.40	0.086	0.038	0.248
12.34	121.06	74	11.06	5.73	63.37	1.91	0.112	0.061	0.296
15.15	148.62	88	10.91	5.6	61.10	2.43	0.124	0.082	0.352
17.96	176.19	100	10.75	5.55	59.66	2.95	0.137	0.090	0.4
20.76	203.66	109	10.54	5.49	57.86	3.52	0.153	0.100	0.436
23.57	231.22	119	10.32	5.33	55.00	4.20	0.171	0.126	0.476
26.38	258.79	125	10.14	5.28	53.54	4.83	0.185	0.134	0.5
29.2	286.45	132	9.98	5.21	51.99	5.51	0.198	0.146	0.528
32.01	314.02	139	9.66	5.17	49.94	6.28	0.224	0.152	0.556
32.82	321.96	144	9.42	5.09	47.94	6.71	0.243	0.166	0.576
37.63	369.15	151	9.19	5.03	46.22	7.98	0.262	0.175	0.604
40.45	396.81	155	9	4.98	44.82	8.85	0.277	0.184	0.62
43.26	424.38	159	8.76	4.91	43.01	9.86	0.296	0.195	0.636
46.1	452.24	167	8.45	4.87	41.15	10.99	0.321	0.201	0.668
48.9	479.9	173	8.21	4.81	39.50	12.15	0.340	0.211	0.692
51.7	507.6	181	8.03	4.74	38.06	13.34	0.355	0.223	0.724



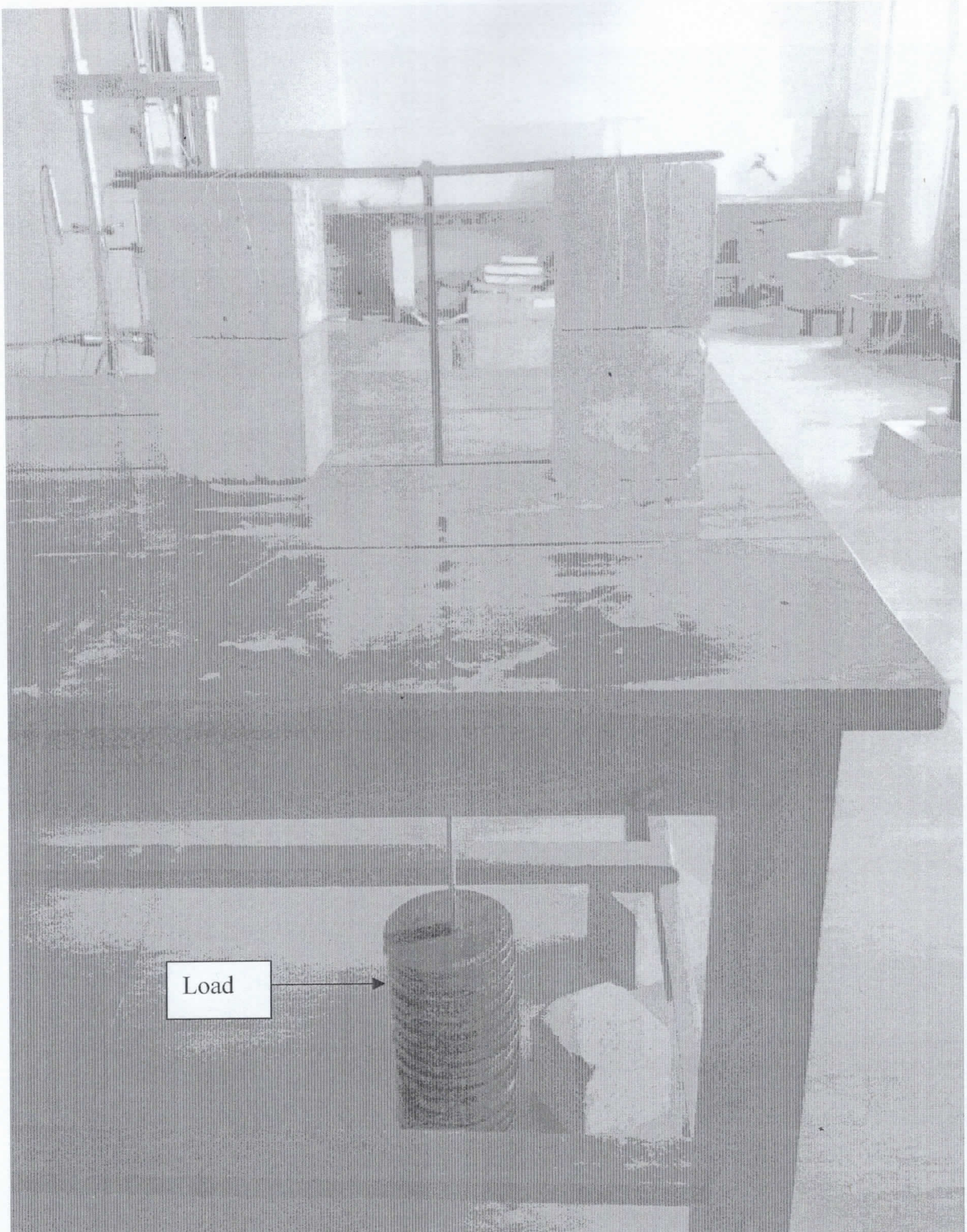
Graph 5.48.stress strain curve

Tensile strength of the tyre rope = 507.6/38.06

= 13.34 N/mm^2

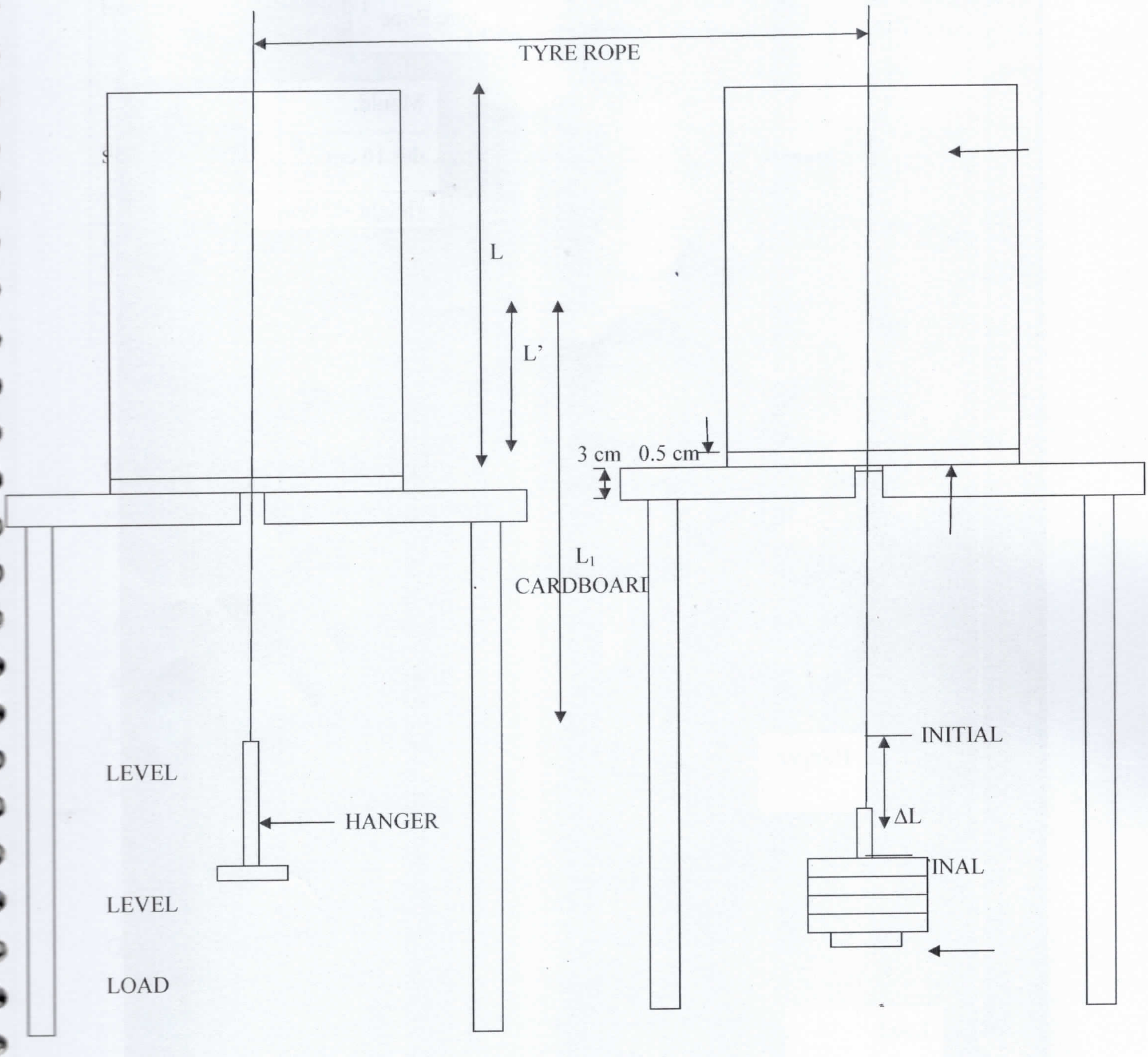


PICTURE 4 Tensile strength Test setup before applying load.

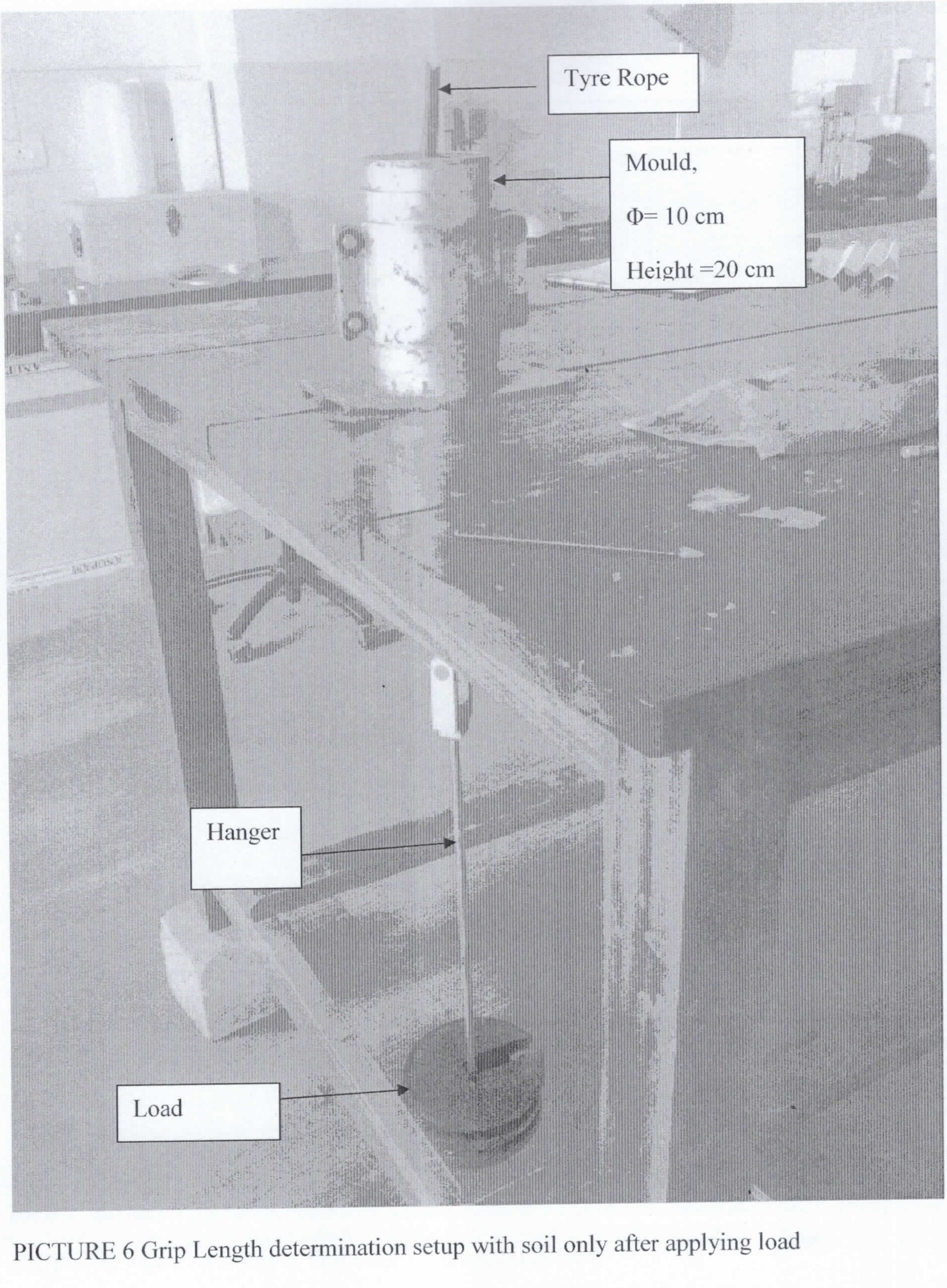


PICTURE 5 Tensile strength Test setup after applying load.

5.9 Grip length of tyre rope



6. DIAGRAM FOR DETERMINATION OF GRIP LENGTH



PICTURE 6 Grip Length determination setup with soil only after applying load

5.9.1 Grip length test of soil sample without coir

load(kg)	load(N)	length between two reference points (cm) ref. point	displacement (cm)	net displacement (ΔL) (cm)
0	0	10	0	0
1.085	10.59	10.8	0.8	0.8
3.898	38.16	12	1.2	2
6.711	65.83	13.3	1.3	3.3
9.524	93.43	14.6	1.3	4.6
12.337	121.06	16.4	`1.8	6.4
15.15	148.62	18.6	1.2	8.6

Table 5.50.Grip length test for soil sample only

Grip length of tyre rope of sample without coir

Failure stress = (15.15*9.81)/61.1 N/mm^2

=2.43 N/mm^2

$\Delta L/L_1$ = 0.35 (from stress-strain curve corresponding to failure stress)

ΔL = 86mm

L_1 = 245.71mm

L' = 245.71 - 100 - 30 - 5

= 110.71mm

Grip length = L – L'

= 200 – 110.71

= 89.29mm

Bond strength = (15.15*9.81)/89.29*(12.45*6.1)

= 0.089 N/mm^2

5.9.2Grip length test of soil sample with coir of 0.5% by weight of soil sample and coir length half inch

load(kg)	load(N)	length between two reference points (cm) ref. point	displacement (cm)	net displacement (ΔL) (cm)
0	0	9.8	0	0
1.085	10.59	10.9	1.1	1.1
3.898	38.16	11.4	0.5	1.6
6.711	65.83	12.6	1.2	2.8
9.524	93.43	13.9	1.3	4.1
12.337	121.06	15	1.1	5.2
15.15	148.62	16.7	1.7	6.9
17.96	176.19	19.3	2.6	9.5

Table 5.51.Grip length test for soil sample with coir 0.5% and coir length half inch

Grip length of tyre rope of sample with coir(0.5% by weight and ½ inch length)

Failure stress = (17.96*9.81)/59.66 N/mm^2

=2.95 N/mm^2

$\Delta L/L_1$ = 0.4 (from stress-strain curve corresponding to failure stress)

ΔL = 95mm

L_1 = 237.5mm

L' = 237.5 - 98 - 30 - 5

= 104.5mm

Grip length = L – L'

= 200 – 104.5

= 95.5mm

Bond strength = (17.96*9.81)/95.5*(12.45*6.1)

= 0.099 N/mm^2

5.9.3 Grip length test of soil sample with coir of 1% by weight of soil sample and coir length half inch

load(kg)	load(N)	length between two reference points (cm) ref. point	displacement (cm)	net displacement (ΔL) (cm)
0	0	10.1	0	0
1.085	10.59	11	0.9	0.9
3.898	38.16	11.7	0.7	1.6
6.711	65.83	13.1	1.4	3
9.524	93.43	14.8	1.7	4.7
12.337	121.06	16.2	1.4	6.1
15.15	148.62	18.3	2.1	8.2
17.96	176.19	19.8	1.5	9.7

Table 5.52.Grip length Test for soil and 1% coir and coir length half inch

Grip length of tyre rope of sample with coir (1% by weight and ½ inch length)

Failure stress = (17.96*9.81)/59.66 N/mm^2

=2.95 N/mm^2

$\Delta L/L_1$ = 0.4 (from stress-strain curve corresponding to failure stress)

ΔL = 97mm

L_1 = 242.5mm

L' = 242.5 - 101 - 30 - 5

= 106.5mm

Grip length = L – L'

= 200 – 106.5

= 93.5mm

Bond strength = (17.96*9.81)/93.5*(12.45+6.1)

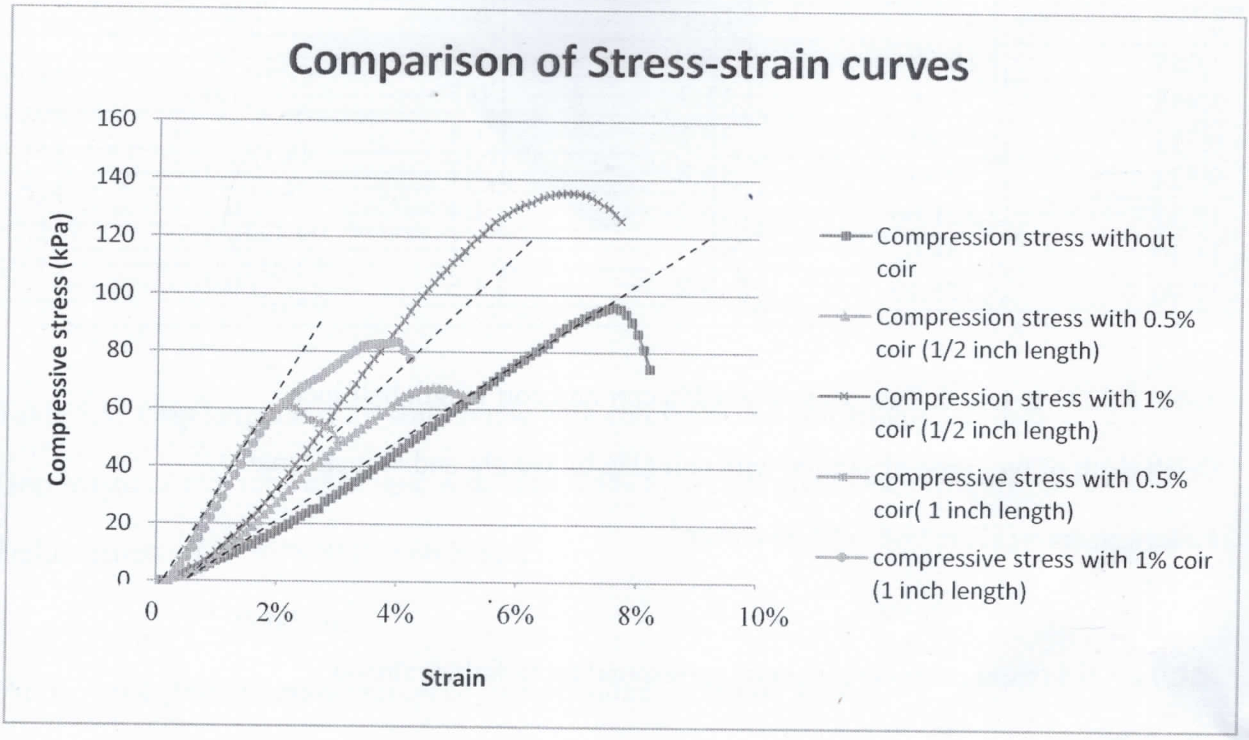
= 0.101 N/mm^2

CHAPTER 6

ANALYSIS OF RESULTS

6.1 Unconfined Compressive Strength Test

The results of all the unconfined compression tests carried out in this work are shown below:



Graph 6.1.Comparison of UC Test results

From Unconfined Compression Tests different failure strains for different samples are observed as below:

Sample description	Failure strain
Soil without coir	7.4%
Soil mixed with 1.0% coir of ½ inch length	6.6%
Soil mixed with 0.5% coir of ½ inch length	4.4%
Soil mixed with 1.0% coir of 1 inch length	4.8%
Soil mixed with 0.5% coir of 1inch length	1.9%

The strain at failure decreases with increase in coir fibre length. For the same fibre length the strain at failure is lower at 0.5% coir than at 1% coir.

The curves show significant reduction in compressive strength of the samples with 0.5% coir. But the effect of mixing 1% coir on the compressive strength of the mixture is not conclusive from the present test results.

Although the coir mixed soil samples fail at lower strain for a given applied compressive load (up to 60 kPa) the corresponding strain is 30% lower for ½ inch coir fibre mixed soil and is 50% lower for 1 inch coir fibre mixed soil in comparison to strain in soil without coir. This is demonstrated by the approximate linear stress-strain curves shown as dashed lines in the figure above.

So the soil mixed with coir under unconfined condition has higher modulus of elasticity and, when subjected to loading within the compressive strength, shall result in lesser settlement than soil without coir.

The results of the test revealed that using coir increases the stability of soil. When coir were used along with the soil, it is found that strain corresponding to particular compressive stress is much lower than that of soil which don't have coir in it. As stain is lesser, it implies that lateral forces acting on the plinth wall due to the infill soil is also less. Since lateral pressure on the gets reduced, the thickness of the plinth wall can be reduced without disturbing the stability of the wall. On today era the importance of cost effective building is much high. So all avenues regarding the cost reduction must be explored and alternative measures must be used which not only provides stability to the building but also cost effective and environment friendly. Use of coir not only improves the strength of soil but also reduces the cost of construction as it is cheap, easily available.

6.2 Direct Shear Test

Comparison for all stress- strain curves for 50 kPa normal stress (1/2 inch coir length)

strain	Shear stress(kPa) for 50 kPanormal stress for 0.25% coir (1/2 inch)	Shear stress(kPa) for 50 kPa normal stress for 0.5% coir (1/2 inch)	Shear stress(kPa) for 50 kPa normal stress for 0.75% coir (1/2 inch)	Shear stress(kPa) for 50 kPa normal stress for 1% coir (1/2 inch)
0	0	0	0	0
0.003333333	7.357859532	7.357859532	15.38461538	10.03344482
0.006666667	11.40939597	11.40939597	21.47651007	13.42281879
0.01	17.50841751	15.48821549	26.93602694	17.50841751
0.013333333	22.2972973	19.59459459	30.40540541	20.94594595
0.016666667	25.76271186	23.72881356	33.89830508	23.72881356
0.02	27.89115646	27.89115646	35.37414966	26.53061224
0.023333333	29.35153584	31.39931741	36.86006826	28.66894198
0.026666667	30.1369863	34.93150685	37.67123288	30.82191781
0.03	30.24054983	38.48797251	37.80068729	32.3024055
0.033333333	31.03448276	41.37931034	37.93103448	33.79310345
0.036666667	31.14186851	43.59861592	38.06228374	34.60207612
0.04	31.25	45.13888889	38.19444444	35.41666667
0.043333333	31.35888502	46.68989547	38.32752613	36.93379791
0.046666667	32.16783217	47.55244755	38.46153846	37.76223776
0.05	32.98245614	47.71929825	38.59649123	37.89473684
0.053333333	33.09859155	47.88732394	38.73239437	38.73239437
0.056666667	33.2155477	47.34982332	39.57597173	39.57597173

0.06	33.33333333	46.09929078	39.71631206	40.42553191
0.063333333	33.4519573	44.83985765	39.85765125	40.56939502
0.066666667	33.57142857	44.28571429	40	40.71428571
0.07	33.69175627		40.86021505	41.57706093
0.073333333	33.81294964		41.00719424	42.44604317
0.076666667	33.93501805		41.15523466	43.32129964
0.08	34.05797101		41.30434783	44.20289855
0.083333333	34.18181818		41.45454545	43.63636364
0.086666667	34.30656934		42.33576642	44.52554745
0.09	34.43223443		42.49084249	44.68864469
0.093333333	34.55882353		42.64705882	46.32352941
0.096666667	34.68634686		42.80442804	46.49446494
0.1	34.81481481		42.96296296	46.66666667
0.103333333	34.94423792		43.12267658	47.58364312
0.106666667	35.07462687		44.02985075	48.50746269
0.11	35.20599251		44.19475655	48.68913858
0.113333333	35.33834586		44.36090226	50.37593985
0.116666667	35.47169811		44.52830189	50.56603774
0.12	36.36363636		44.6969697	50.75757576
0.123333333	36.50190114		45.62737643	51.71102662
0.126666667	36.64122137		45.80152672	51.90839695
0.13	36.7816092		45.97701149	52.10727969
0.133333333	36.92307692		46.15384615	52.30769231
0.136666667	37.06563707		46.33204633	52.50965251
0.14	37.20930233		46.51162791	52.71317829
0.143333333	37.3540856		46.692607	53.69649805
0.146666667	37.5		46.875	53.90625
0.15	37.64705882		47.05882353	54.11764706

Table 6.2.1.Comparison for all stress- strain curves for 50 kPa normal stress (1/2 inch coir length)

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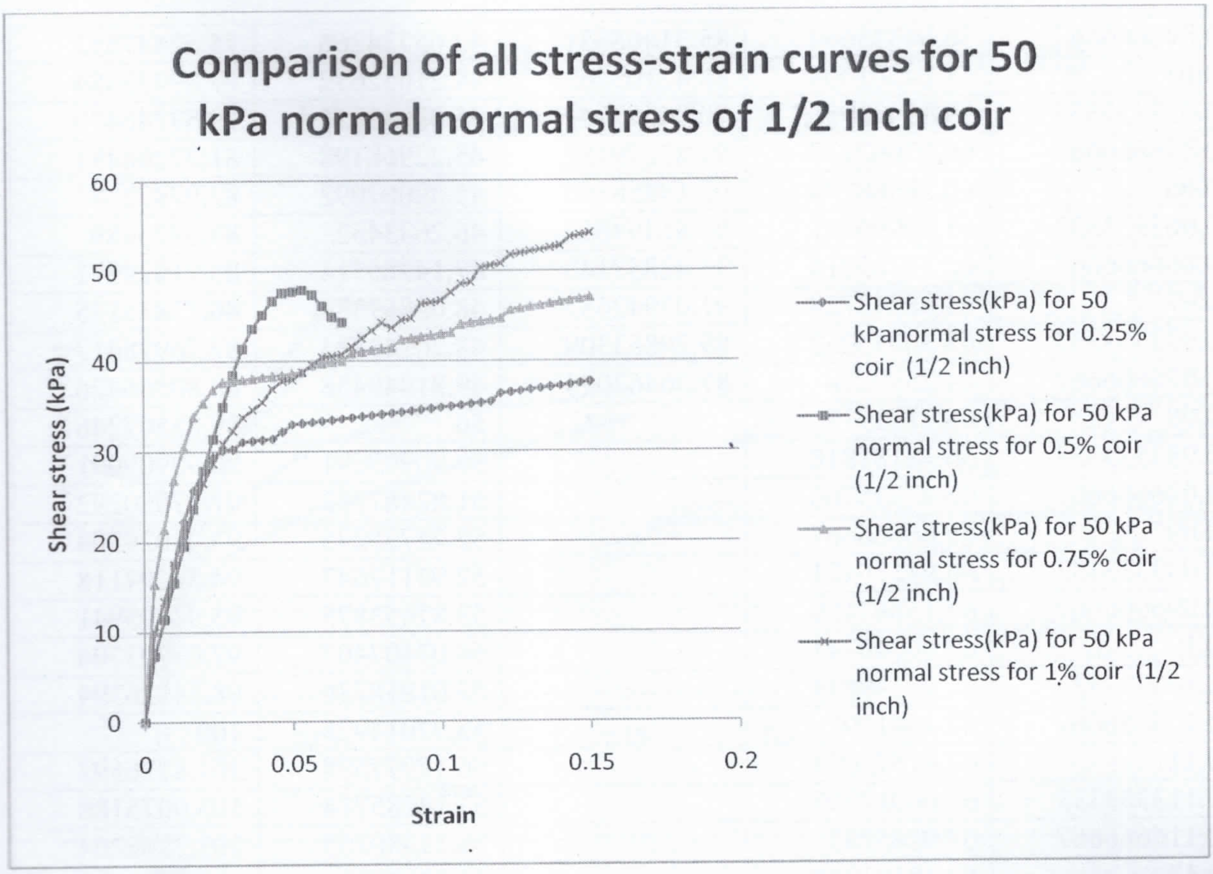


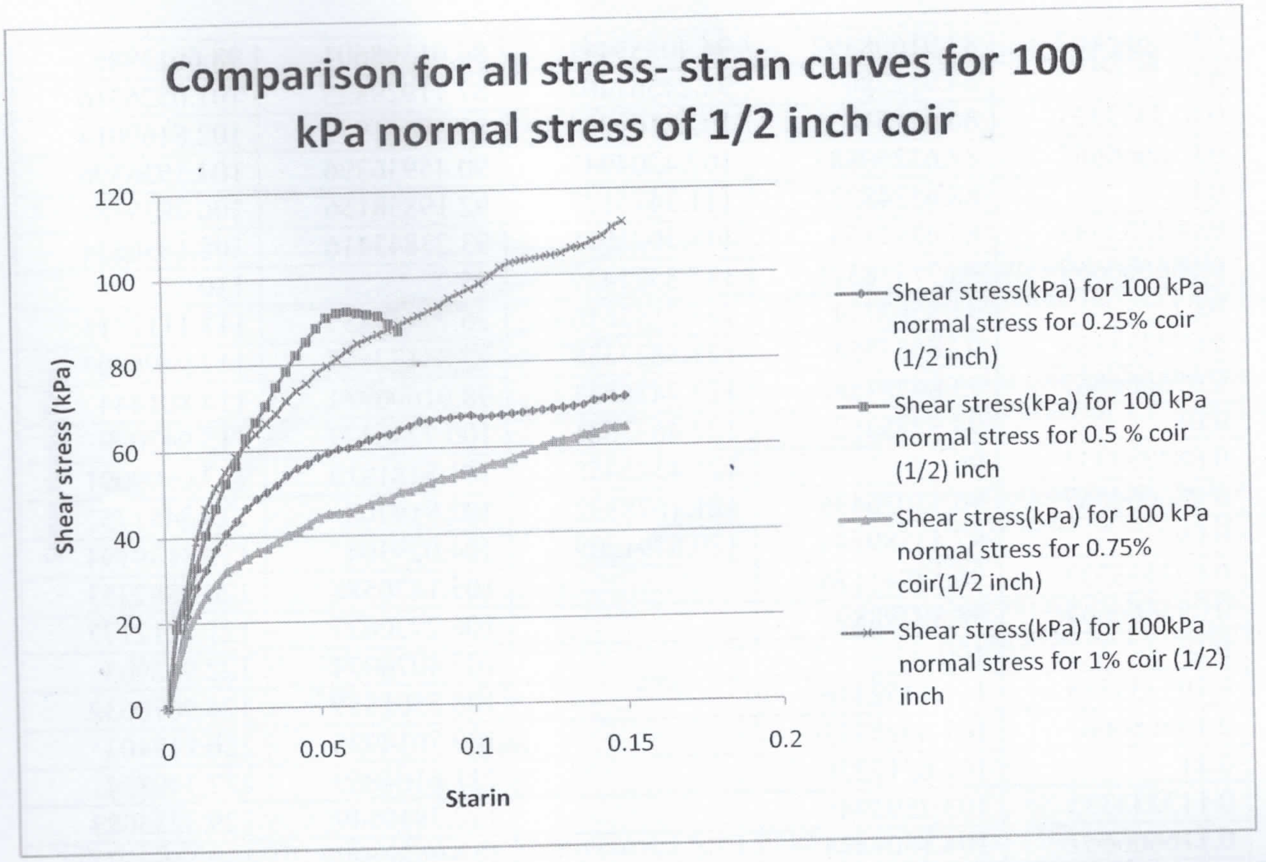
Graph 6.2.1.Comparison for all stress- strain curves for 50 kPa normal stress (1/2 inch coir length)

Comparison for all stress- strain curves for 100 kPa normal stress (1/2 inch coir)

strain	Shear stress(kPa) for 100 kPa normal stress for 0.25% coir (1/2 inch)	Shear stress(kPa) for 100 kPa normal stress for 0.5 % coir (1/2) inch	Shear stress(kPa) for 100 kPa normal stress for 0.75% coir(1/2 inch)	Shear stress(kPa) for 100kPa normal stress for 1% coir (1/2) inch
0	0	0	0	0
0.003333333	10.03344482	18.72909699	9.364548495	20.06688963
0.006666667	21.47651007	24.16107383	17.44966443	27.51677852
0.01	28.28282828	32.996633	22.22222222	39.05723906
0.013333333	32.43243243	40.54054054	26.35135135	46.62162162
0.016666667	37.28813559	46.77966102	29.15254237	51.52542373
0.02	40.81632653	52.38095238	31.97278912	55.10204082
0.023333333	43.68600683	56.6552901	33.44709898	58.70307167
0.026666667	46.57534247	63.01369863	34.93150685	61.64383562
0.03	48.79725086	66.66666667	36.42611684	63.91752577
0.033333333	50.34482759	70.34482759	37.24137931	66.20689655
0.036666667	51.90311419	74.74048443	38.75432526	68.51211073
0.04	54.16666667	78.47222222	40.27777778	71.52777778
0.043333333	55.74912892	82.22996516	41.11498258	73.86759582

0.046666667	56.64335664	85.31468531	42.65734266	75.52447552
0.05	58.24561404	88.42105263	44.21052632	77.89473684
0.053333333	59.15492958	90.84507042	45.07042254	79.57746479
0.056666667	60.07067138	91.87279152	45.22968198	81.27208481
0.06	60.28368794	92.19858156	45.39007092	82.9787234
0.063333333	61.20996441	91.81494662	46.2633452	84.6975089
0.066666667	62.14285714	91.42857143	47.14285714	85.71428571
0.07	63.08243728	91.03942652	48.02867384	86.73835125
0.073333333	63.30935252	89.20863309	48.20143885	87.76978417
0.076666667	64.2599278	87.36462094	49.81949458	88.80866426
0.08	65.2173913		50	89.85507246
0.083333333	66.18181818		50.90909091	90.90909091
0.086666667	66.42335766		51.82481752	91.97080292
0.09	66.66666667		52.74725275	93.04029304
0.093333333	66.91176471		52.94117647	94.85294118
0.096666667	67.15867159		53.87453875	95.94095941
0.1	67.40740741		54.07407407	97.03703704
0.103333333	66.91449814		55.01858736	98.14126394
0.106666667	67.1641791		55.97014925	100
0.11	67.41573034		56.17977528	101.8726592
0.113333333	67.66917293		57.14285714	103.0075188
0.116666667	67.9245283		58.11320755	103.3962264
0.12	68.18181818		59.09090909	103.7878788
0.123333333	68.44106464		60.07604563	104.1825095
0.126666667	68.70229008		61.06870229	104.5801527
0.13	68.96551724		61.30268199	104.9808429
0.133333333	69.23076923		61.53846154	106.1538462
0.136666667	69.4980695		62.54826255	106.5637066
0.14	70.54263566		62.79069767	107.751938
0.143333333	70.81712062		63.81322957	108.9494163
0.146666667	71.09375		64.0625	110.9375
0.15	71.37254902		64.31372549	112.1568627

Table 6.2.2.Comparison for all stress- strain curves for 100 kPa normal stress (1/2 inch coir)



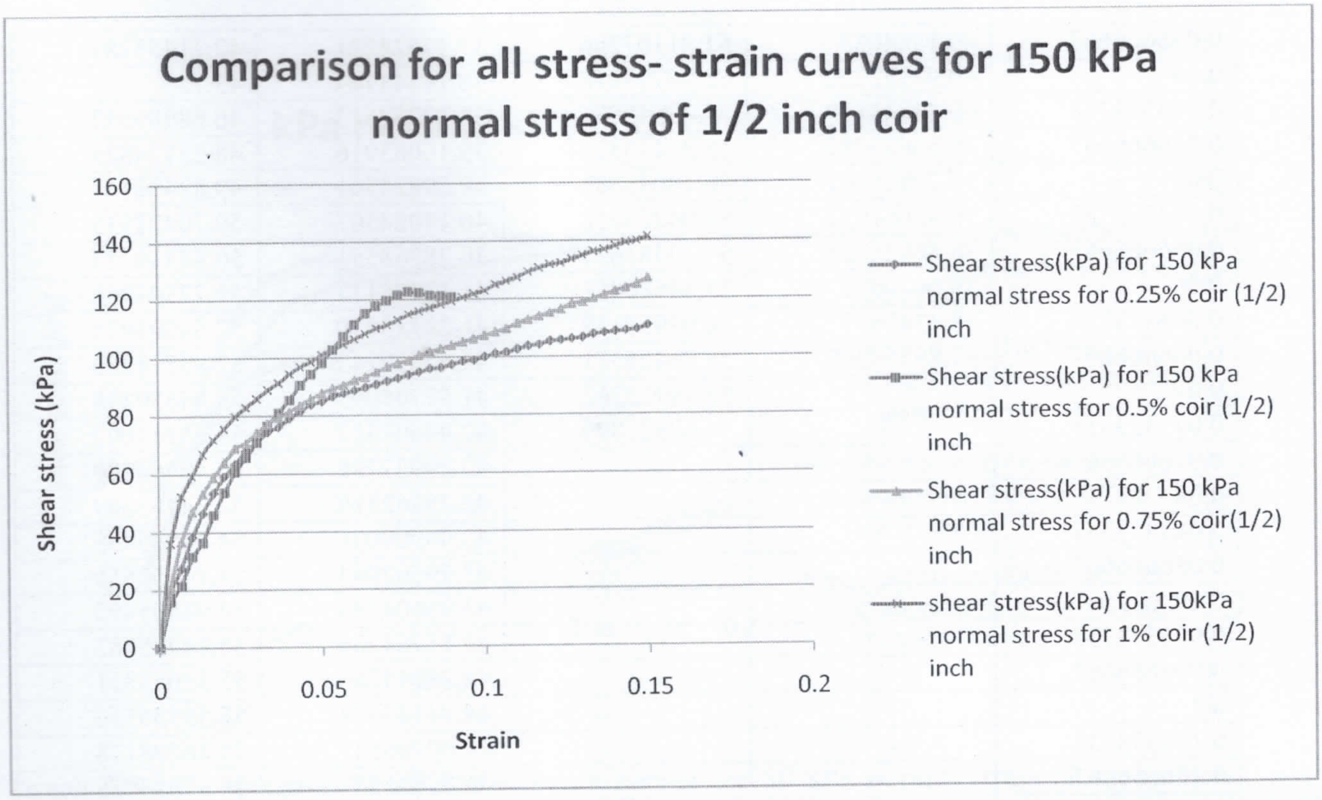
Graph 6.2.2.Comparison for all stress- strain curves for 100 kPa normal stresses (1/2 inch coir)

Comparison for all stress- strain curves for 150 kPa normal stress (1/2 inch coir)

strain	Shear stress(kPa) for 150 kPa normal stress for 0.25% coir (1/2) inch	Shear stress(kPa) for 150 kPa normal stress for 0.5% coir (1/2) inch	Shear stress(kPa) for 150 kPa normal stress for 0.75% coir(1/2) inch	shear stress(kPa) for 150kPa normal stress for 1% coir (1/2) inch
0	0	0	0	0
0.003333333	19.39799331	16.05351171	20.73578595	36.12040134
0.006666667	27.51677852	21.47651007	36.91275168	52.34899329
0.01	38.38383838	31.64983165	47.13804714	59.25925926
0.013333333	46.62162162	36.48648649	53.37837838	66.89189189
0.016666667	53.55932203	46.10169492	58.98305085	71.86440678
0.02	59.18367347	53.7414966	63.94557823	75.51020408
0.023333333	63.48122867	60.75085324	68.94197952	79.86348123
0.026666667	67.80821918	65.75342466	70.54794521	82.87671233
0.03	70.79037801	70.79037801	74.22680412	85.91065292
0.033333333	74.48275862	76.55172414	77.24137931	88.96551724
0.036666667	76.12456747	80.96885813	79.58477509	91.34948097
0.04	79.16666667	85.41666667	81.25	94.44444444
0.043333333	81.53310105	90.59233449	83.62369338	96.8641115

0.046666667	83.91608392	94.40559441	86.01398601	98.6013986
0.05	84.9122807	98.24561404	87.71929825	101.0526316
0.053333333	86.61971831	102.8169014	89.43661972	102.8169014
0.056666667	87.63250883	107.4204947	90.45936396	104.5936396
0.06	88.65248227	111.3475177	92.19858156	106.3829787
0.063333333	89.6797153	115.3024911	93.23843416	108.1850534
0.066666667	90.71428571	117.8571429	95	110
0.07	91.7562724	119.7132616	96.77419355	111.1111111
0.073333333	92.8057554	121.5827338	97.84172662	112.9496403
0.076666667	93.86281588	122.7436823	98.91696751	114.801444
0.08	94.92753623	122.4637681	100.7246377	115.942029
0.083333333	96	121.4545455	101.8181818	117.0909091
0.086666667	96.35036496	121.1678832	102.919708	118.2481752
0.09	97.43589744	120.8791209	104.029304	119.4139194
0.093333333	98.52941176		105.1470588	120.5882353
0.096666667	98.89298893		106.2730627	121.7712177
0.1	100		107.4074074	122.962963
0.103333333	101.1152416		108.5501859	124.9070632
0.106666667	101.4925373		109.7014925	126.119403
0.11	102.6217228		111.6104869	127.340824
0.113333333	103.7593985		112.7819549	129.3233083
0.116666667	104.1509434		113.9622642	130.5660377
0.12	105.3030303		115.1515152	131.8181818
0.123333333	105.7034221		116.3498099	132.3193916
0.126666667	106.1068702		118.3206107	133.5877863
0.13	106.51341		118.7739464	134.8659004
0.133333333	107.6923077		120	136.1538462
0.136666667	108.1081081		121.2355212	136.6795367
0.14	108.5271318		122.4806202	137.9844961
0.143333333	108.9494163		123.7354086	139.2996109
0.146666667	109.375		125	139.84375
0.15	110.5882353		127.0588235	141.1764706

Table 6.2.3.Comparison for all stress- strain curves for 150 kPa normal stress (1/2 inch coir)



Graph 6.2.3.Comparison for all stress- strain curves for 150 kPa normal stress (1/2 inch coir)

By comparing all the DST curves of 0.25%, 0.5%, 0.75% and 1% for ½ inch coir fibres for 50,100 and 150kPa normal stresses, it is found that shear strength increases when amount of coir is increased from 0.25% to 0.5%, then it gets reduced at 0.75% and finally it again increases at 1% for all three normal stresses. From the graph, it can be inferred that optimum coir content for increasing the shear strength of soil is 0.5%.

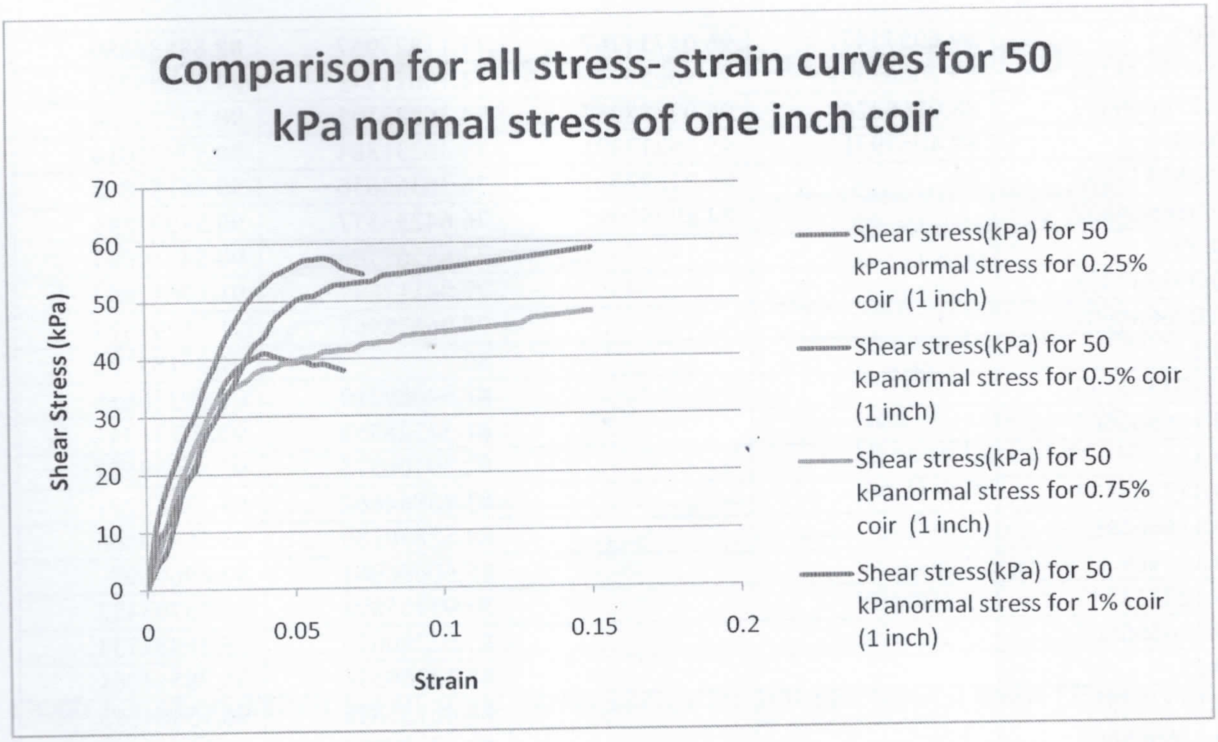
6.3 Direct Shear Test

Comparison for all stress- strain curves for 50 kPa normal stress (1 inch coir length)

Strain	Shear stress(kPa) for 50 kPanormal stress for 0.25% coir (1 inch)	Shear stress(kPa) for 50 kPanormal stress for 0.5% coir (1 inch)	Shear stress(kPa) for 50 kPanormal stress for 0.75% coir (1 inch)	Shear stress(kPa) for 50 kPanormal stress for 1% coir (1 inch)
0	0	0	0	0
0.003333333	4.013377926	11.37123746	5.351170569	8.026755853
0.006666667	6.711409396	17.44966443	10.73825503	10.73825503
0.01	12.79461279	22.22222222	16.83501684	14.81481481
0.013333333	18.91891892	27.02702703	20.94594595	18.24324324
0.016666667	21.01694915	30.50847458	25.08474576	21.69491525
0.02	28.57142857	35.37414966	28.57142857	26.53061224
0.023333333	32.08191126	38.90784983	32.08191126	29.35153584
0.026666667	35.61643836	43.15068493	33.56164384	32.87671233
0.03	37.80068729	46.04810997	35.05154639	35.73883162
0.033333333	39.31034483	48.96551724	35.86206897	39.31034483

0.036666667	40.1384083	51.21107266	37.37024221	42.21453287
0.04	40.97222222	52.77777778	38.19444444	43.75
0.043333333	40.41811847	54.3554007	38.32752613	46.68989547
0.046666667	39.86013986	55.24475524	39.16083916	48.25174825
0.05	39.29824561	56.14035088	39.29824561	49.8245614
0.053333333	39.43661972	57.04225352	40.14084507	50.70422535
0.056666667	38.86925795	57.24381625	40.28268551	50.88339223
0.06	39.0070922	57.44680851	41.13475177	51.77304965
0.063333333	38.4341637	56.93950178	41.28113879	52.66903915
0.066666667	37.85714286	55.71428571	41.42857143	52.85714286
0.07		55.19713262	41.57706093	53.04659498
0.073333333		54.67625899	42.44604317	53.23741007
0.076666667			42.59927798	53.42960289
0.08			42.75362319	54.34782609
0.083333333			42.90909091	54.54545455
0.086666667			43.79562044	54.74452555
0.09			43.95604396	54.94505495
0.093333333			44.11764706	55.14705882
0.096666667			44.2804428	55.35055351
0.1			44.44444444	55.55555556
0.103333333			44.60966543	55.76208178
0.106666667			44.7761194	55.97014925
0.11			44.94382022	56.17977528
0.113333333			45.11278195	56.39097744
0.116666667			45.28301887	56.60377358
0.12			45.45454545	56.81818182
0.123333333			45.62737643	57.03422053
0.126666667			45.80152672	57.2519084
0.13			46.74329502	57.47126437
0.133333333			46.92307692	57.69230769
0.136666667			47.1042471	57.91505792
0.14			47.28682171	58.13953488
0.143333333			47.47081712	58.36575875
0.146666667			47.65625	58.59375
0.15			47.84313725	58.82352941

Table 6.3.1.Comparison for all stress- strain curves for 50 kPa normal stress (1 inch coir length)



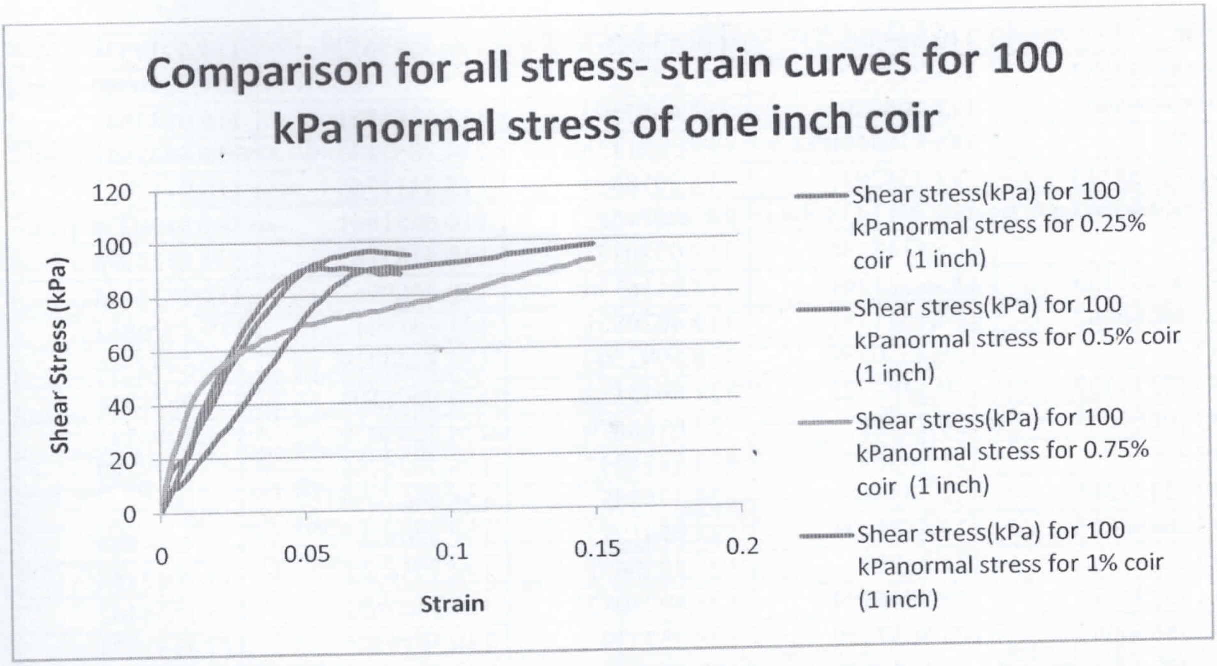
Graph 6.3.1.Comparison for all stress- strain curves for 50 kPa normal stress (1 inch coir length)

Comparison for all stress- strain curves for 100 kPa normal stress (1 inch coir length)

Strain	Shear stress(kPa) for 100 kPanormal stress for 0.25% coir (1 inch)	Shear stress(kPa) for 100 kPanormal stress for 0.5% coir (1 inch)	Shear stress(kPa) for 100 kPanormal stress for 0.75% coir (1 inch)	Shear stress(kPa) for 100 kPanormal stress for 1% coir (1 inch)
0	0	0	0	0
0.003333333	14.71571906	6.688963211	17.39130435	8.026755853
0.006666667	18.79194631	14.76510067	27.51677852	10.06711409
0.01	21.54882155	23.56902357	38.38383838	14.14141414
0.013333333	34.45945946	31.08108108	45.27027027	18.91891892
0.016666667	42.03389831	37.28813559	49.49152542	23.05084746
0.02	49.65986395	44.21768707	53.06122449	27.89115646
0.023333333	55.97269625	51.87713311	55.97269625	31.39931741
0.026666667	62.32876712	57.53424658	58.21917808	36.30136986
0.03	68.72852234	63.23024055	60.48109966	41.2371134
0.033333333	73.79310345	68.96551724	62.06896552	46.89655172
0.036666667	78.89273356	73.35640138	64.35986159	51.90311419
0.04	82.63888889	77.77777778	65.27777778	56.25
0.043333333	85.71428571	82.22996516	66.8989547	62.02090592
0.046666667	88.11188811	86.01398601	67.83216783	66.43356643
0.05	89.8245614	89.12280702	69.47368421	71.57894737
0.053333333	90.14084507	91.54929577	69.71830986	76.05633803
0.056666667	90.45936396	92.5795053	70.67137809	79.15194346
0.06	90.07092199	94.32624113	71.63120567	82.9787234
0.063333333	90.39145907	94.66192171	71.886121	85.40925267
0.066666667	90	95.71428571	72.85714286	87.85714286

0.07	89.60573477	96.05734767	73.11827957	88.88888889
0.073333333	89.20863309	96.4028777	74.10071942	89.92805755
0.076666667	88.0866426	96.02888087	74.36823105	90.25270758
0.08	88.4057971	95.65217391	75.36231884	90.57971014
0.083333333	88	95.27272727	76.36363636	90.18181818
0.086666667		94.89051095	76.64233577	90.51094891
0.09			77.65567766	90.84249084
0.093333333			77.94117647	91.17647059
0.096666667			78.96678967	91.51291513
0.1			80	91.85185185
0.103333333			81.04089219	92.19330855
0.106666667			81.34328358	92.53731343
0.11			82.39700375	92.88389513
0.113333333			83.45864662	93.23308271
0.116666667			84.52830189	93.58490566
0.12			85.60606061	94.6969697
0.123333333			85.93155894	95.05703422
0.126666667			87.02290076	95.41984733
0.13			88.12260536	95.78544061
0.133333333			88.46153846	96.15384615
0.136666667			89.57528958	96.52509653
0.14			89.92248062	96.89922481
0.143333333			91.05058366	97.27626459
0.146666667			92.1875	97.65625
0.15			92.54901961	98.03921569

Table 6.3.2.Comparison for all stress- strain curves for 50 kPa normal stress (1 inch coir length)



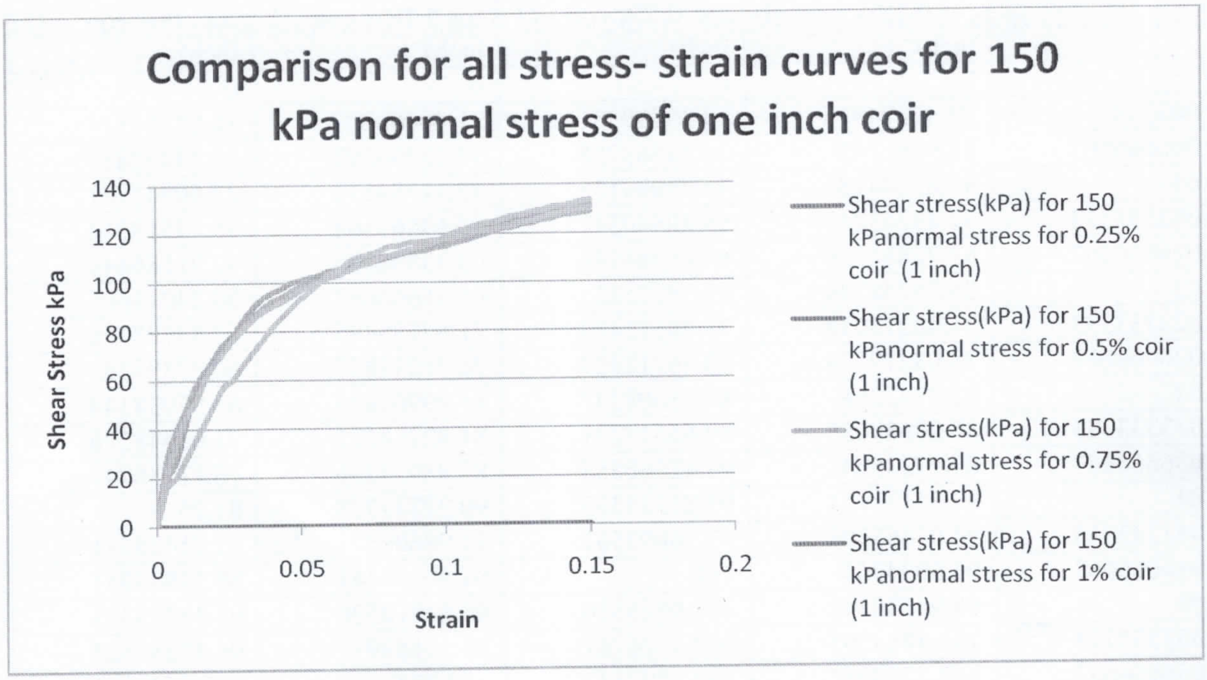
Graph 6.3.2.Comparison for all stress- strain curves for 100 kPa normal stress (1 inch coir length)

Comparison for all stress- strain curves for 150 kPa normal stress (1 inch coir length)

Strain	Shear stress(kPa) for 150 kPanormal stress for 0.25% coir (1 inch)	Shear stress(kPa) for 150 kPanormal stress for 0.5% coir (1 inch)	Shear stress(kPa) for 150 kPanormal stress for 0.75% coir (1 inch)	Shear stress(kPa) for 150 kPanormal stress for 1% coir (1 inch)
0	0	0	0	0
0.003333333	27.42474916	19.39799331	21.40468227	16.05351171
0.006666667	38.9261745	26.84563758	33.55704698	20.13422819
0.01	47.81144781	41.75084175	45.11784512	27.60942761
0.013333333	57.43243243	55.40540541	50.67567568	35.13513514
0.016666667	63.72881356	63.05084746	60.33898305	42.71186441
0.02	68.70748299	69.3877551	66.66666667	50.34013605
0.023333333	74.40273038	75.08532423	71.67235495	57.33788396
0.026666667	78.08219178	78.76712329	76.71232877	60.2739726
0.03	82.4742268	84.53608247	81.09965636	65.97938144
0.033333333	86.20689655	89.65517241	84.82758621	71.03448276
0.036666667	89.2733564	93.42560554	87.88927336	76.12456747
0.04	92.36111111	95.83333333	90.27777778	81.25
0.043333333	94.07665505	97.56097561	91.98606272	85.71428571
0.046666667	96.5034965	100	94.40559441	89.51048951
0.05	98.94736842	101.0526316	96.84210526	93.33333333
0.053333333	101.4084507	102.1126761	98.5915493	96.47887324
0.056666667	102.4734982	103.180212	100.3533569	100.3533569
0.06	104.2553191	104.964539	102.1276596	103.5460993
0.063333333	105.3380783	105.3380783	103.202847	105.3380783
0.066666667	106.4285714	107.1428571	105	108.5714286
0.07	107.5268817	107.5268817	106.8100358	110.3942652
0.073333333	109.352518	107.9136691	107.9136691	111.5107914
0.076666667	110.4693141	109.0252708	109.7472924	112.6353791

0.08	110.8695652	110.1449275	110.8695652	114.4927536
0.083333333	111.2727273	111.2727273	112	114.9090909
0.086666667	112.4087591	112.4087591	113.1386861	116.0583942
0.09	112.8205128	113.5531136	114.2857143	116.4835165
0.093333333	113.2352941	114.7058824	115.4411765	116.9117647
0.096666667	114.3911439	115.8671587	116.6051661	117.3431734
0.1	114.8148148	117.037037	118.5185185	117.7777778
0.103333333	115.9851301	118.2156134	120.4460967	118.2156134
0.106666667	117.1641791	119.4029851	121.641791	119.4029851
0.11	118.3520599	120.5992509	122.8464419	120.5992509
0.113333333	119.5488722	121.8045113	124.0601504	121.0526316
0.116666667	120.754717	123.0188679	124.5283019	121.509434
0.12	121.969697	124.2424242	125.7575758	122.7272727
0.123333333	122.4334601	125.4752852	126.9961977	123.1939163
0.126666667	123.6641221	125.9541985	127.480916	124.4274809
0.13	124.137931	127.2030651	128.7356322	124.9042146
0.133333333	125.3846154	127.6923077	129.2307692	126.1538462
0.136666667	125.8687259	128.957529	130.5019305	127.4131274
0.14	127.1317829	129.4573643	131.0077519	127.9069767
0.143333333	127.6264591	129.9610895	131.5175097	129.1828794
0.146666667	128.125	131.25	132.8125	129.6875
0.15	128.627451	131.7647059	133.3333333	130.1960784

Table 6.3.3.Comparison for all stress- strain curves for 150 kPa normal stress (1 inch coir length).



Graph 6.3.3.Comparison for all stress- strain curves for 150 kPa normal stress (1 inch coir length)

The direct shear test curves conducted for various % of 1 inch long fibres shows higher strength for samples with 0.5% coir than samples with 0.25% coir. But for samples with higher % of coir fibres, although the strength is lower than that for 0.5% coir, the curves do not gives a conclusive trend.

The shear parameters obtained from the direct shear tests are tabulated below:

Sample Description	**Cohesion (c) in kPa**	**Friction Angle (ϕ)**
Soil without coir	10	26°54'
Soil with 0.25% coir fibre (½ inch)	01	36°06'
Soil with 0.50% coir fibre (½ inch)	02	39°48'
Soil with 0.75% coir fibre (½ inch)	04	38°39'
Soil with 1.00% coir fibre (½ inch)	08	41^0
Soil with 0.25% coir fibre (1 inch)	0	41°23'
Soil with 0.50% coir fibre (1 inch)	21	36°37'
Soil with 0.75% coir fibre (1 inch)	06	40°30'
Soil with 1.00% coir fibre (1 inch)	24	35°30'

The results shows that there is 40-50% improvement of the friction angle of the samples with the addition of ½ inch long coir fibres. But the soil initially losses its cohesion after addition of the ½ inch coir fibres.

In case of the results with 1 inch long fibres the test results does not give any acceptable trend.

Tyre Rope:

The tests with the tyre ropes shows that tensile strength of the rope is13.34 N/mm^2. The tyre rope has a bond strength of 0.09 N/mm^2 with soil used in this work. The bond strength increases with the use of coir to 0.1 N/mm^2.

CHAPTER 7

CONCLUSION

The strain at failure decreases with increase in coir fibre length. For the same fibre length the strain at failure is lower at 0.5% coir than at 1% coir.

The curves show significant reduction in compressive strength of the samples with 0.5% coir. But the effect of mixing 1% coir on the compressive strength of the mixture is not conclusive from the present test results.

Although the coir mixed soil samples fail at lower strain for a given applied compressive load (up to 60 kPa) the corresponding strain is 30% lower for ½ inch coir fibre mixed soil and is 50% lower for 1 inch coir fibre mixed soil in comparison to strain in soil without coir. This is demonstrated by the approximate linear stress-strain curves shown as dashed lines in the figure above.

So the soil mixed with coir under unconfined condition has higher modulus of elasticity and, when subjected to loading within the compressive strength, shall result in lesser settlement than soil without coir.

By comparing all the DST curves of 0.25%, 0.5%, 0.75% and 1% for ½ inch coir fibres for 50,100 and 150kPa normal stresses, it is found that shear strength increases when amount of coir is increased from 0.25% to 0.5%, then it gets reduced at 0.75% and finally it again increases at 1% for all three normal stresses. From the graph, it can be inferred that optimum coir content for increasing the shear strength of soil is 0.5%.

The direct shear test curves conducted for various % of 1 inch long fibres shows higher strength for samples with 0.5% coir than samples with 0.25% coir. But for samples with higher % of coir fibres, although the strength is lower than that for 0.5% coir, the curves do not gives a conclusive trend.

The results shows that there is 40-50% improvement of the friction angle of the samples with the addition of ½ inch long coir fibres. But the soil initially losses its cohesion after addition of the ½ inch coir fibres.

In case of the results with 1 inch long fibres the test results does not give any acceptable trend.

Tyre Rope:

The tests with the tyre ropes shows that tensile strength of tyre rope is 13.34 N/mm^2. The tyre rope has a bond strength of 0.09 N/mm^2 with soil used in this work. The bond strength increases with the use of coir to 0.1 N/mm^2.

The results of the test revealed that using coir increases the stability of soil. When coir were used along with the soil, it is found that strain corresponding to particular compressive stress is much lower than that of soil which don't have coir in it. As stain is lesser, it implies that lateral forces acting on the plinth wall due to the infill soil is also less. Since lateral pressure on the gets reduced, the thickness of the plinth wall can be reduced without disturbing the stability of the wall. On today era the importance of cost effective building is much high. So all avenues regarding the cost reduction must be explored and alternative measures must be used which not only provides stability to the building but also cost effective and environment friendly. Use of coir not only improves the strength of soil but also reduces the cost of construction as it is cheap, easily available. While in case of tyre rope, there is 10% increase in bond strength when coir is used along with it which led to conclusion that it has a potential of being used as anchor material.

Statement of Expenditure

Project Title: A Study on Reduction of Building Plinth Wall Thickness by Application of Coir/Jute as Geotextile and Waste Material as Anchor Bar

Registration Number: **DoRD/CE/UKD/20-236**

Amount Sanctioned: **Rs 90,324/- (Rupees Ninety Thousand Three Hundred Twenty Four Only)**

Expenditure (Reference: TU/11-18/Pur/Civil/2015/4799 dated: 11/3/2015) (See Page **A5**)

Items	**Amount**	**Bill Forwarding Number**	**Reference**
Laboratory Equipment	Rs 90,205	TU/CE/Pur/12-F.13/249; Dated: 09/11/2015 See Page **A6**	See page **A6-A7**
Total	Rs90,205/- (Rupees Ninety Thousand Two Hundred Five Only)		

16/10/17

(Utpal Kumar Das)

F-13 A6 o/c

DEPARTMENT OF CIVIL ENGINEERING
TEZPUR UNIVERSITY
(A Central University established by an Act of Parliament)
NAPAAM :: TEZPUR – 784 028 :: ASSAM

Ref. TU/CE/Pur/12-F.13/ 249

Dt. 09-11-2015

To
The Finance Officer
Tezpur University, Tezpur

Sub: Payment request of concerned parties

Sir,

I am submitting herewith bill-cum-invoice against the supply of Geotechnical Engineering Laboratory items by M/s Aimil Ltd., Naimex House, A-8 Mohan Co-operative Industrial Estate, Mathura Road, New Delhi-110044 to the Dept. of Civil Engineering in January, 2015 for your needful action.

Thanking you,

Yours sincerely,

(Shailen Deka)
Head i/c
Dept of Civil Engineering

Encl:

i. Summary of balance against sanction amount
ii. Original bill-cum-invoice(2 copies)
iii. Copy of the Purchase Order
iv. Sanction Order
vi. Warranty Certificate

Aimil Ltd.
Instrumentation & Technologies

Corporate Office: Naimex House, A-8, Mohan Co-operative Industrial Estate, Mathura Road, New Delhi - 110044, India
Phone : 91-11-30810200, Fax: 91-11-26950011, Email: info@aimil.com, Website: www.aimil.com

RETAIL INVOICE

Customer	C07014	TEZPUR UNIVERSITY DEPUTY REGISTRAR (GA) OFFICE OF THE REGISTRAR NAPAAM, TEZPUR - 784028 ASSAM (India)	Invoice No. Dated OA No. Dated	R114989 26/03/15 C143392 13/03/15

Contact: MR. CHIRAJYOTI DOLEY, Tel: 03712-267007/8/9, 8723082052

Consignee	00003	TEZPUR UNIVERSITY THE HOD CIVIL ENGINEERING DEPT. NAPAAM, TEZPUR - 784028 ASSAM (India)

Contact: MR. CHIRAJYOTI DOLEY, Tel: 03712-267007/8/9, 8723082052

Customer Order No.	TU/11-18/PUR/CIVIL/2015/4199	Dated11/03/15
Worksheet No.	C15-1421	Dated13/03/15

No.	Description	Quantity	Unit	Unit Price	Disc %	Amount
	Shipment No. PLT145509: OA No. C143392:					
AIM-02402	'A' Drill Rod, 1m long complete with adapter	7	NO	2,508.00	10.00	15,800.40
AIM-271	Integral Type Compression Proving Ring with Pads, Capacity 25kN (2,500 kgf)	1	NO	15,890.00	10.00	14,301.00
AIM-9473	Dessicator Vaccum Type, 250mm dia	2	NO	4,585.00	10.00	8,253.00
AIM-006	Sampling Tube, unrelieved, 38mm dia x 200mm long, pair	2	PAIR	850.00	10.00	1,530.00

Items are received & installed successfully
Chirajyoti D.
Technical Officer
Department of Civil Engineering
Tezpur University

Sub Total	39,884.40
Total Sale Value before adding CST	39,884.40
CST@ (12.5 %)	4,985.56
Total Sale Price with CST (Rs.)	44,869.96
Invoice Rounding	0.04
Net Amount	44,870.00

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Dated 24/03/15

H.O.D. I/c
Department of Civil Engineering
Tezpur University

Assistant Professor
Department of Civil Engineering
Tezpur University

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Customer C07014 TEZPUR UNIVERSITY
DEPUTY REGISTRAR (GA)
OFFICE OF THE REGISTRAR
NAPPAM, TEZPUR - 784028

Inv. No. R114989A
Inv. Date 26/03/2015

Consignee 00003 THE HOD
CIVIL ENGG DEPT.
TEZPUR UNIVERSITY
OFFICE OF THE REGISTRAR
NAPPAM, TEZPUR - 784028

OA No. C143392
OA Date 13/03/2015

Customer Order No. TU/11-18/Pur/Civil/2015/4799 Dated 11/03/2015
Worksheet No. C15-1421 Dated 13/03/2015

Cat. No.	Description	Qty.	Unit	Unit Price	Amount
AIM-01702	Shoe, hardened with an inside cutting edge	1	No.	1270.50	1270.50
MIS 27949	Electronic Balance, Capacity 6000g x 0.1g	1	No.	29580.00	29580.00
AIM 031-S1	Hand Operated Extractor for 38mm & 50 mm dia specimen	1	No.	13925.00	13925.00
	Sub. Total				44775.50
	Less : Discount 10%				4477.55
					40297.95
	CST @ (12.5%)				5037.24
	Total Sale Price with CST (Rs.)				45335.19
				R/O	45335.00

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Items are received and installed successfully. [signature]

Technical Officer
Department of Civil Engineering
Tezpur University

For AIMIL Ltd.

[signature]

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Tezpur University

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