“Improvement in Shear Strength of soil using Polypropylene and Coir fibre”

A PROJECT

Submitted in partial fulfilment of the requirements for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

Under the supervision of

Mr. Abhilash Shukla

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By

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to

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY

WAKNAGHAT SOLAN – 173 234

HIMACHAL PRADESH INDIA

June, 2016

CERTIFICATE

This is to certify that the work which is being presented in the project title **"Study On improvement in shear strength of soil using polypropylene and coir fibre"** in partial fulfillment of the requirements for the award of the degree of Bachelor of technology and submitted in Civil Engineering Department, Jaypee University of Information Technology, Waknaghat is an authentic record of work carried out by **Akhilesh Gandhi (121687)** and **Shubham Sharma (121688)** during a period from July 2015 to June 2016 under the supervision of **Mr. Abhilash Shukla, Assistant Professor**, Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat.

The above statement made is correct to the best of my knowledge.

Date: - ………………………

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DECLARATION

We hereby declare that the project entitled "**Study on Strength Properties of Fibre Reinforced Concrete**" submitted by us to Jaypee University of Information Technology, Waknaghat in partial fulfillment of the Degree of Bachelor of Technology in Civil Engineering is a record of bona fide project work carried out by us under the guidance of **Mr. AbhilashShukla**. The information submitted herein is true and original.

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Acknowledgement

We wish to express our earnest gratitude to our esteemed mentor Mr Abhilash Shukla, for providing us invaluable guidance and suggestions, which inspired us to take up such a challenge. He not only cleared all our doubts but also generated a high level of interest in the subject. We are truly grateful to him. We extend an utmost gratitude to the lab in-charge, Mr. Itesh Singh for this support and guidance while conduction various experiments.

The prospect of working in a group with a high level of accountability fostered a spirit of teamwork and created a feeling of oneness which thus, expanded our range of vision, motivated us to perform to the best of our ability and create a report of the highest quality. To do the best quality work, with utmost sincerity and precision has been our constant endeavour. We extent our deep appreciation and thanks to the authors of various research papers which we referred in order do this project.

ABSTRACT

The main objective of this study is to investigate the use of waste fibre materials in geotechnical applications and to evaluate the effects of waste polypropylene fibres and coconut coir on shear strength of saturated soil by carrying out soil samples. The results obtained and inferences are drawn towards the usability and effectiveness of fibre reinforcement as a replacement for deep foundation or raft foundation, as a cost effective approach. Our main aim in the project will be to find fibre content which improves shear strength of soil in most cost effective manner.

We can thus conclude that addition of fibre improve the load bearing capacity of soil by increasing its shear strength.

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CHAPTER-1

INTRODUCTION

For any land-based structure, the foundation is very important and has to be strong to support the entire structure. In order for the foundation to be strong, the soil around it plays a very critical role. So, to work with soils, we need to have proper knowledge about their properties and factors which affect their behaviour. The process of soil stabilization helps to achieve the required properties in a soil needed for the construction work.

From the beginning of construction work, the necessity of enhancing soil properties has come to the light. Ancient civilizations of the Chinese, Romans and Incas utilized various methods to improve soil strength etc., some of these methods were so effective that their buildings and roads still exist.

In India, the modern era of soil stabilization began in early 1970's, with a general shortage of petroleum and aggregates, it became necessary for the engineers to look at means to improve soil other than replacing the poor soil at the building site. Soil stabilization was used but due to the use of obsolete methods and also due to the absence of proper technique, soil stabilization lost favour. In recent times, with the increase in the demand for infrastructure, raw materials and fuel, soil stabilization has started to take a new shape. With the availability of better research, materials and equipment, it is emerging as a popular and cost-effective method for soil improvement.

Here, in this project, soil stabilization has been done with the help of randomly distributed polypropylene fibres obtained from waste materials. The improvement in the shear strength parameters has been stressed upon and comparative studies have been carried out using different methods of shear resistance measurement.

CHAPTER -2

LITERATURE REVIEW

2.1 Soil Stabilization

2.1.1 Definition

Soil stabilization is the process of altering some soil properties by different methods, mechanical or chemical in order to produce an improved soil material which has all the desired engineering properties.

Soils are generally stabilized to increase their strength and durability or to prevent erosion and dust formation in soils. The main aim is the creation of a soil material or system that will hold under the design use conditions and for the designed life of the engineering project. The properties of soil vary a great deal at different places or in certain cases even at one place; the success of soil stabilization depends on soil testing. Various methods are employed to stabilize soil and the method should be verified in the lab with the soil material before applying it on the field.

Principles of Soil Stabilization:

•Evaluating the soil properties of the area under consideration.

• Deciding the property of soil which needs to be altered to get the design value and choose the effective and economical method for stabilization.

• Designing the Stabilized soil mix sample and testing it in the lab for intended stability and durability values.

2.1.2 Needs & Advantages

Soil properties vary a great deal and construction of structures depends a lot on the bearing capacity of the soil, hence, we need to stabilize the soil which makes it easier to predict the load bearing capacity of the soil and even improve the load bearing capacity.

The gradation of the soil is also a very important property to keep in mind while working with soils. The soils may be well-graded which is desirable as it has less number of voids or uniformly graded which though sounds stable but has more voids. Thus, it is better to mix different types of soils together to improve the soil strength properties. It is very expensive to replace the inferior soil entirely soil and hence, soil stabilization is the thing to look for in these cases. It improves the strength of the soil, thus, increasing the soil bearing capacity. It is more economical both in terms of cost and energy to increase the bearing capacity of the soil rather than going for deep foundation or raft foundation.

It is also used to provide more stability to the soil in slopes or other such places. Sometimes soil stabilization is also used to prevent soil erosion or formation of dust, which is very useful especially in dry and arid weather. Stabilization is also done for soil water-proofing; this prevents water from entering into the soil and hence helps the soil from losing its strength.

It helps in reducing the soil volume change due to change in temperature or moisture content. Stabilization improves the workability and the durability of the soil.

2.1.3 Methods

1. Mechanical method of Stabilization

In this procedure, soils of different gradations are mixed together to obtain the desired property in the soil. This may be done at the site or at some other place from where it can be transported easily. The final mixture is then compacted by the usual methods to get the required density.

2. Additive method of stabilization

It refers to the addition of manufactured products into the soil, which in proper quantities enhances the quality of the soil. Materials such as cement, lime, bitumen, fly ash etc. are used as chemical additives. Sometimes different fibres are also used as reinforcements in the soil. The addition of these fibres takes place by two methods :

a) Oriented fibre reinforcement-

The fibres are arranged in some order and all the fibres are placed in the same orientation. The fibres are laid layer by layer in this type of orientation. Continuous fibres in the form of sheets, strips or bars etc. are used systematically in this type of arrangement.

b) Random fibre reinforcement-

This arrangement has discrete fibres distributed randomly in the soil mass. The mixing is done until the soil and the reinforcement form a more or less homogeneous mixture. Materials used in this type of reinforcements are generally derived from paper, nylon, metals or other materials having varied physical properties. Randomly distributed fibres have some advantages over the systematically distributed fibres. Somehow this way of reinforcement is similar to addition of admixtures such as cement, lime etc. Besides being easy to add and mix, this method also offers strength isotropy, decreases chance of potential weak planes which occur in the other case and provides ductility to the soil.

2.1.4 Stress strain response in direct shear test and influence of length of fibre on shear strength

Sivakumar Babu and Vasudevan (2008)[5] investigated the strength and stiffness response of coir fibre-reinforced tropical silty soil of intermediate plasticity, and reported the effect of fibre content and fibre length on the strength and stiffness characteristics of the soil. 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%.Maximumimprovement 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 . Esna-ashari8 used cord waste fibre to reinforce the sandy soil. They found that the inclusion of tire cord fibre can change significantly the brittle behaviour of sandy soil to more ductile and also increased both the peak strength and angle of internal friction of sand .The increase of aspect ratio resulted in increasing the shear strength.

Gray and Ohashi (1983)[1] conducted a series of direct shear tests on dry sand reinforced with different synthetic, natural and metallic fibre to evaluate the effects of parameters such as fibre orientation, fibre content, fibre area ratios, and fibre stiffness on contribution to shear strength. Based on the test results they concluded that an increase in shear strength is directly proportional to the fibre area ratios and shear strength envelopes for fibre-reinforced sand clearly shows the existence of a threshold confining stress below which the fibre tries to slip or pull out.

Lekha (2004) and Vishnudas et al. (2006)[11] have presented a few case studies of construction and performance monitoring of coir geotextile reinforced bunds and suggested that the use of coir is a cost effective ecological measure compared to stone-pitching and other stabilization measures used in the protection of slopes and bunds in rural areas.

A. Al-Rawas, A. W. Hago and H. Al-Sarmi[9], metallic fibre and discontinuous multi oriented polypropylene elements have been used to reinforce soil and it has been shown that the addition of randomly distributed elements to soils contributes to the increase in strength and stiffness.

The addition of nylon fibre by Kumar and Tabor resulted in significant increase in the residual strength of silty clay soil.

A. Zaimoglu and T. Yetimoglu [6]studied the engineering properties of a clayey soil of low plasticity reinforced by short discrete polypropylene fiber. The effect of fibre content,length, and diameter as well as the influence of soil aggregate size on the strength ofthe fibre-reinforced soil were studied.

2.1.5 Objective

The major objective of the study is to-

1. To check the improvement in shear strength of soil by use of polypropylene and coconut coir by conducting direct shear test.
2. To find fibre content at which improvement in shear strength is maximum.

CHAPTER-3

EXPERIMENTAL INVESTIGATIONS

3.1 Scope of work

The experimental work consists of the following steps:

1. Specific gravity of soil

2. Particle size distribution by sieve analysis

4. Determination of the maximum dry density (MDD) and the corresponding optimum moisture content (OMC) of the soil by Proctor compaction test .

5.Determination of shear strength of soil by direct shear test.

6. Preparation of reinforced soil samples.

7.Determination of shear strength of reinforced samples by direct shear test.

3.2 Materials

Sample-1: Taken from behind the temple in JUIT.

Sample-2: Taken from ground in front of Shastri Bhawan in JUIT.

Sample-3: Taken from forest behind workers mess in JUIT

Sample-4: Taken from Dumehar in Waknaghat.

Reinforcement: 1.Short PP (polypropylene) fibre

2. Coconut coir

3.2.1 Properties of PP fibre

Fibre type	Single fibre
Unit weight	.91gm/cu.cm
Avg. Diameter	.034mm
Avg. Length	12mm
Breaking tensile strength	350Mpa
Modulus of elasticity	3500Mpa
Fusion point	165 deg c
Burning point	590 deg c
Acid and alkali resistance	Very good

3.2.2 Properties of coir fibre

Diameter	.48mm
Specific gravity	.87
Water absorption	104%
Density	2057kg/m^3
Tensile strength	210Mpa
Elastic modulus	2800Mpa

3.4 Brief steps involved in the experiments

3.4.1 Specific gravity of the soil

The specific gravity of soil is the ratio between the weight of the soil solids and weight of equal volume of water. It is measured by the help of a volumetric flask in a very simple experimental setup where the volume of the soil is found out and its weight is divided by the weight of equal volume of water.

Specific Gravity G = (w2-w1)/((w4-w1)-(w3-w2))

W1- Weight of bottle in gms

W2- Weight of bottle + Dry soil in gms

W3- Weight of bottle + Soil + Water

W4- Weight of bottle + Water

Specific gravity is always measured in room temperature and reported to the nearest 0.1.

3.4.2Particle size distribution

The results from sieve analysis of the soil when plotted on a semi-log graph with particle diameter or the sieve size as the abscissa with logarithmic axis and the percentage passing as the ordinate gives a clear idea about the particle size distribution. From the help of this curve, D10 and D60 are determined. This D10 is the diameter of the soil below which 10% of the soil particles lie. The ratio of, D60 and D10 gives the uniformity coefficient (Cu) which in turn is a measure of the particle size range.

3.4.3 Determination of optimum moisture content

The optimum moisture content has been found out by light compaction test. The volume of the mould is 1000cc . The soil is filled in the mould in three layers and each is tamped in by 25 blows. The mass of the soil filled in the mould at varying water contents is measured and bulk density is determined by dividing it with volume of the mould. Maximum dry density is found out by using formula:

= Bulk density/(1+water content%)

3.4.4 Determination of shear strength by direct shear test

Direct shear test is used to determine shear strength of sandy soil. It gives us the value of internal friction. Sampler is used to measure the sample and put it in the shear box having area ($36cm^2$). Normal load is applied from the top . Shear stress is applied horizontally and its value at fixed interval of dial gauge is measured from proving ring.

Figure 1 Shear displacement of reinforced sample

Figure 2 Sheared sample

Figure 3 Reinforced soil sample

Figure 4 Soil sample with coir fibre

Figure 5 Soil Sample with coir fibre

CHAPTER- 4

RESULTS & DISCUSSIONS

4.1 Sieve analysis

SAMPLE-1

Sieve size	Wt. retained(gm)	Cumulative wt.(gm)	%Finer
4.75 mm	70.33	70.33	96.48
2mm	480.7	551.03	72.448
1.18mm	653.3	1204.33	39.78
850micron	376.3	1580.63	20.96
600micron	70	1650.63	17.46
425micron	140	1790.63	10.46
300micron	10	1800.63	9.96
75micron	160	1960.63	1.96
Pan	39.7	2000	0

Table 1 Seive analysis of sample 1

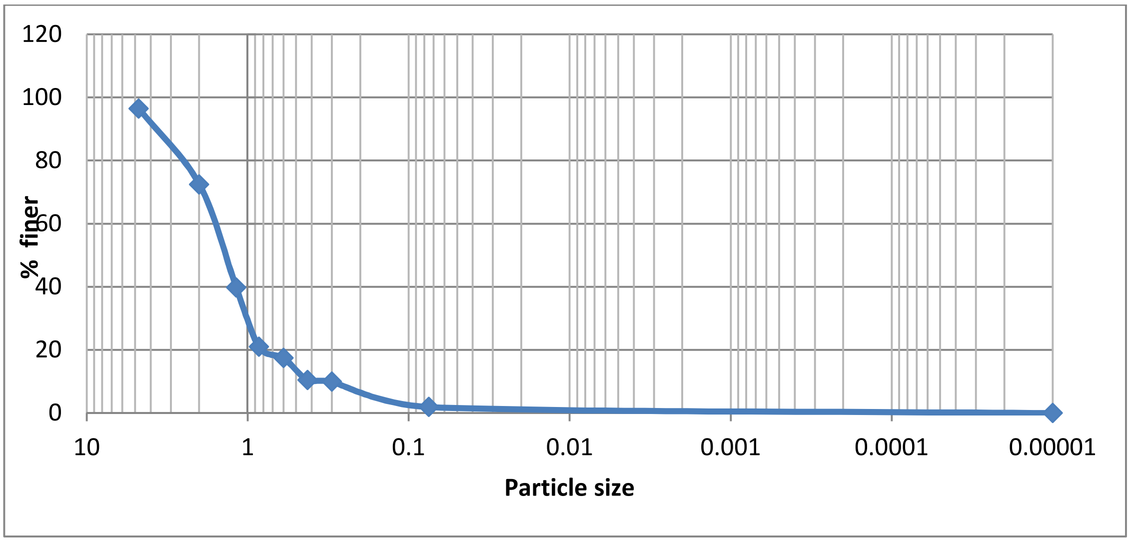


Figure 6 Particle size distribution curve of sample 1

SAMPLE-2

Sieve opening	Weight Retained(gm)	Cumulative Weight(gm)	%finer
4.75 mm	35.3	35.3	98.235
2 mm	508	543.3	72.835
1.18 mm	573.8	1117.1	44.145
850 micron	331.4	1448.5	27.575
600 micron	99.4	1547.9	22.605
425 micron	185.2	1733.1	13.345
300 micron	30	1763.1	11.845
75 micron	179.4	1942.5	2.875
Pan	57.5	2000	0

Table 2 Sieve analysis of sample 2

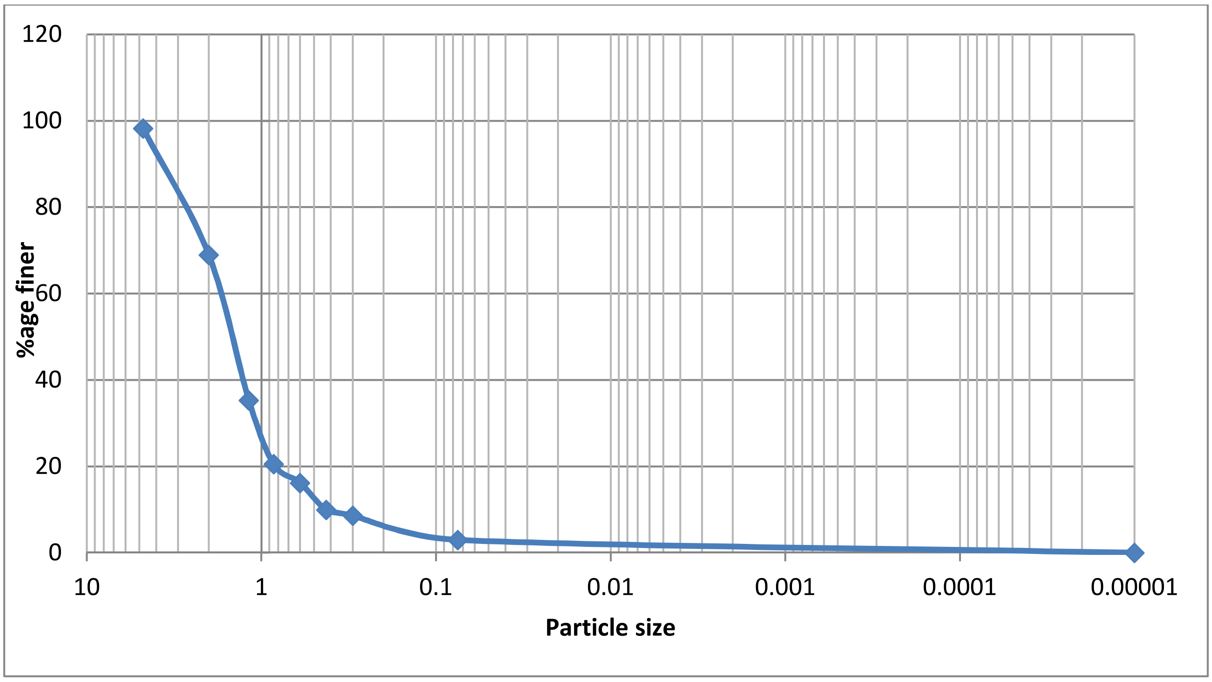


Figure 7 Particle size distribution of sample-2

SAMPLE-3

Sieve size	Weight Retained(gm)	Cumulative Weight(gm)	%finer
4.75 mm	144.8	35.3	98.235
2 mm	585.2	620.5	68.975
1.18 mm	672.4	1292.9	35.355
850 micron	296.6	1589.3	20.535
600 micron	86.4	1675.7	16.215
425 micron	125.2	1800.9	9.955
300 micron	26	1826.9	8.655
75 micron	113.4	1940.3	2.985
Pan	59.7	2000	0

Table 3 Sieve analysis of sample 3

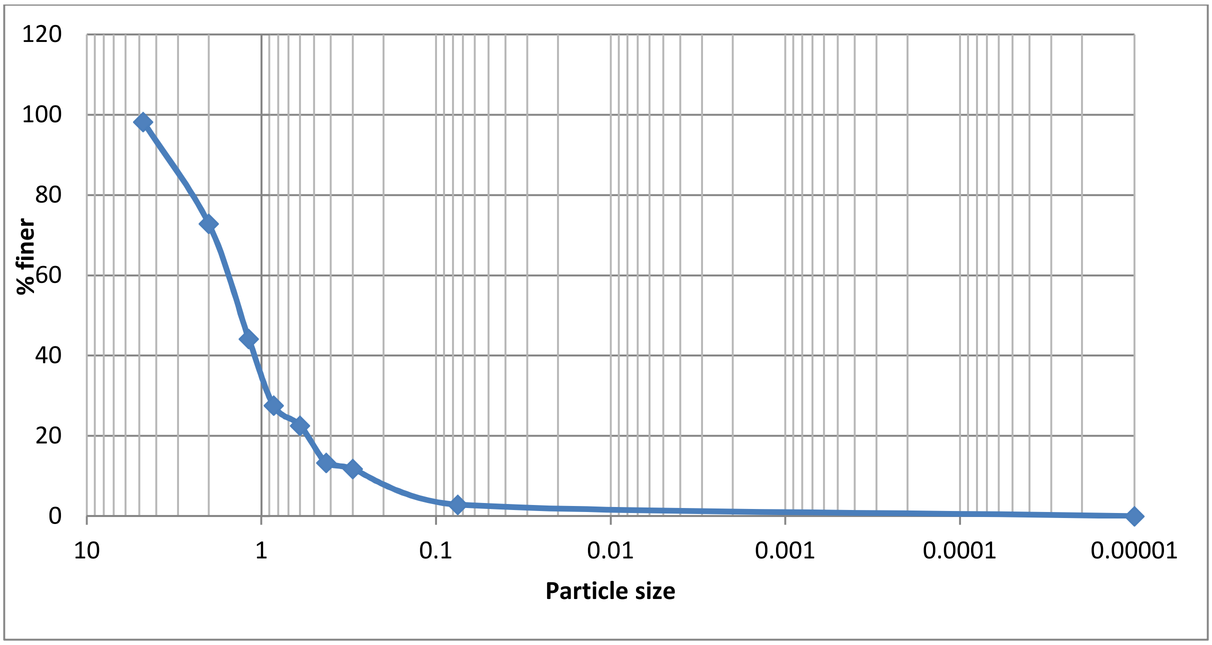


Figure 8 Particle size distribution of sample 3

SAMPLE-4

Sieve size	Weight Retained(gm)	Cumulative Weight(gm)	%finer
4.75 mm	100.2	100.2	94.99
2 mm	290.8	391	80.45
1.18 mm	600	991	50.45
850 micron	320	1311	34.45
600 micron	110	1421	28.95
425 micron	240	1661	16.95
300 micron	30	1691	15.45
150 micron	170	1861	6.95
75micron	70	1931	3.45
Pan	69	2000	0

Table 4 Sieve analyisi of sample 4

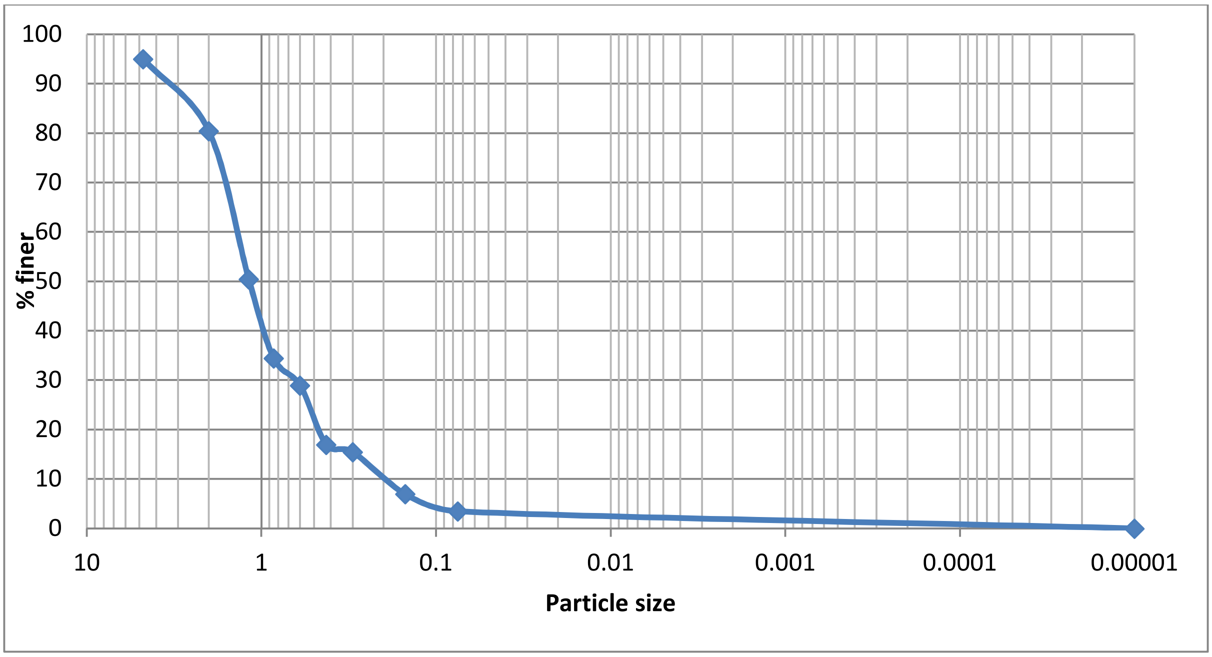


Figure 9 Particle size distribution of sample 4

Coefficient of curvature and uniformity of sample:-

Sample	D10(mm)	D30(mm)	D60(mm)	Cu	Cc
1	.300	.900	1.60	5.33	1.68
2	.280	.870	1.65	5.8	1.83
3	.425	.950	1.5	3.52	1.41
4	.200	.650	1.4	7	1.50

Table 5 Cu and Cc of samples

Soil classification on basis of sieve analysis

Samlpe-1 Well graded gravel

Sample-2 Well graded gravel

Sample -3 Well graded gravel

Sample-4 Well graded sand

Hence , further test will be carried upon Sample-4 .

4.2 Specific Gravity

Only specific gravity of soil sample 4 was tested as this will be used for further investigation.

Weight of empty pycnometer bottle = 445gm

Weight of pycnometer bottle + soil sample = 645gm

Weight of pycnometer bottle + soil sample + water = 1368.3 gm

Weight of pycnometer bottle +water = 1251.4gm

Sp gravity of sample is 2.40

4.3 Optimum moisture content

The optimum moisture of soil came out to be 16%

Water content	Dry density
4%	1.61
7%	1.50
10%	1.68
13%	1.85
16%	1.87
19%	1.71

Table 6 Proctor test table

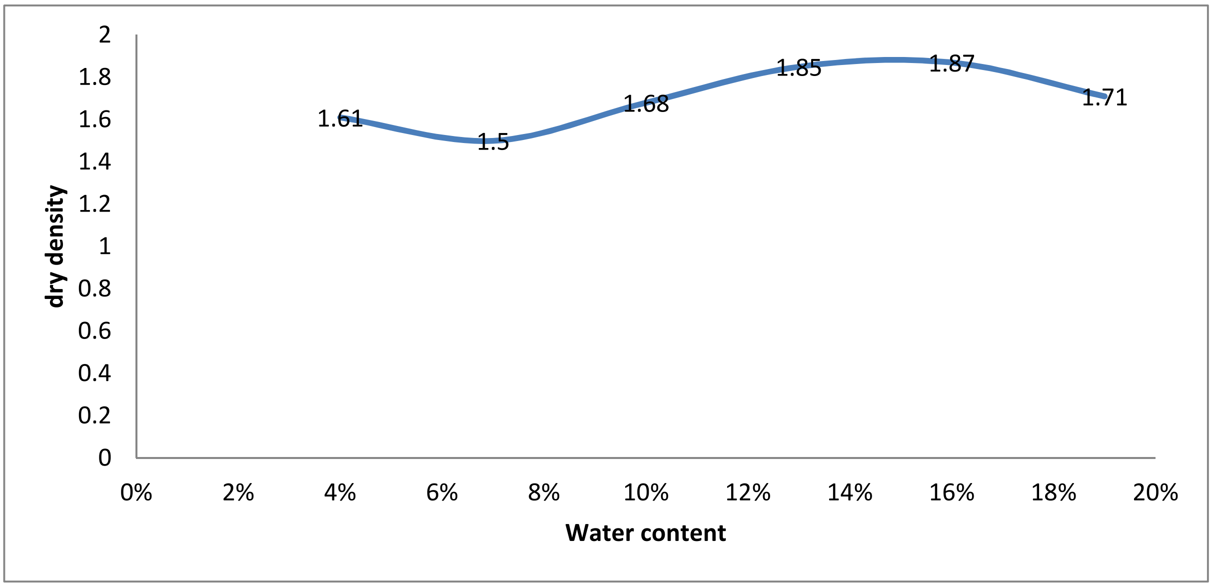


Figure 10 Variation of dry density with water content

From the above graph it can be seen that dry density of the soil initially decreases and starts to increase to optimum value of 1.85.The cause for this initial decrease is phenomenon of bulking which takes place in sand in which water forms a layer around sand particles leading to increase in volume. After certain amount of water this layer breaks leading to decrease in volume hence increase in density.

4 .4 Direct shear test results –

a) Polypropylene fibre

1. Normal load -1.15 kg/cm^2

1.1 Soil without fibre content

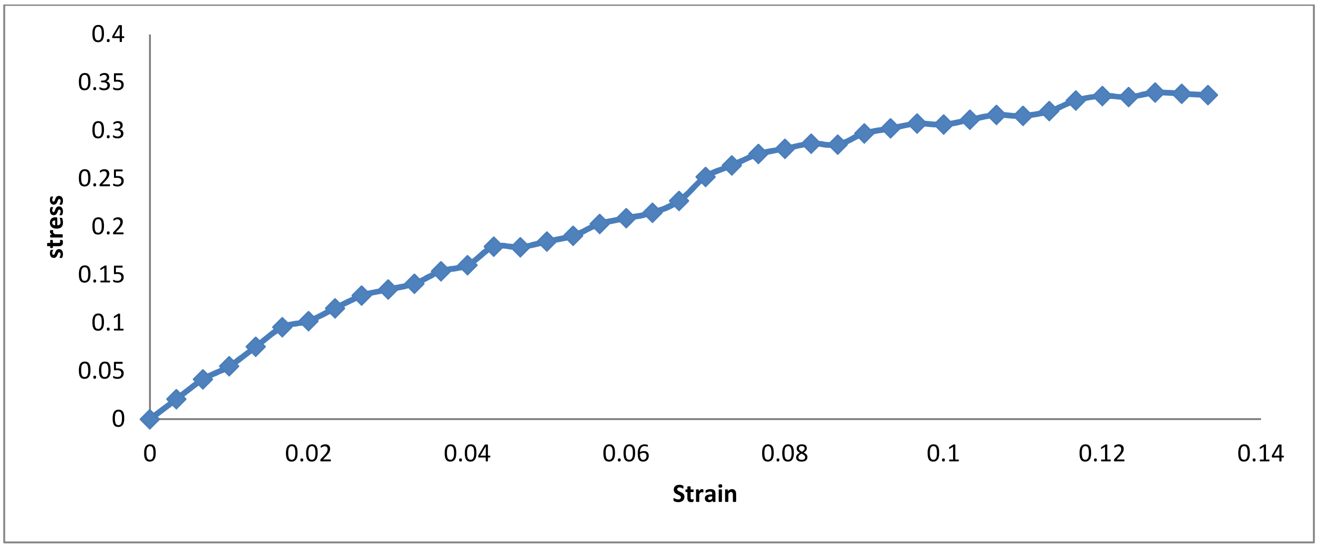


Figure 11 Stress strain curve

From the above graph it can be inferred that stress at failure is .338kg/cm^2

1.2 Soil with 1% fibre content

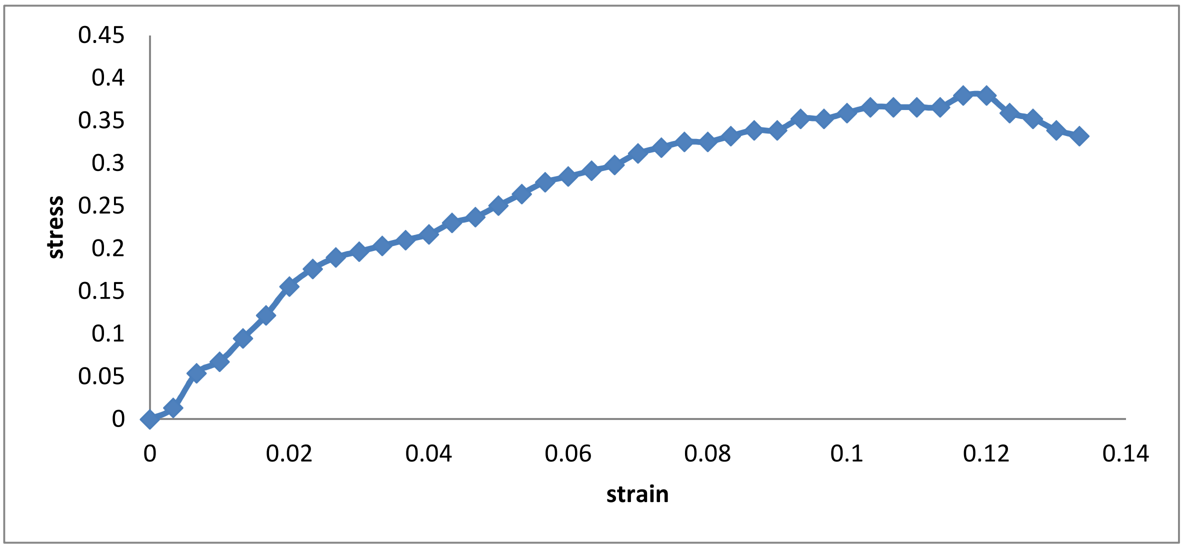


Figure 12 Stress strain curve

From the above graph it can be inferred that stress at failure is - .373kg/cm^2

1.3 Soil with 1.5 % fibre content

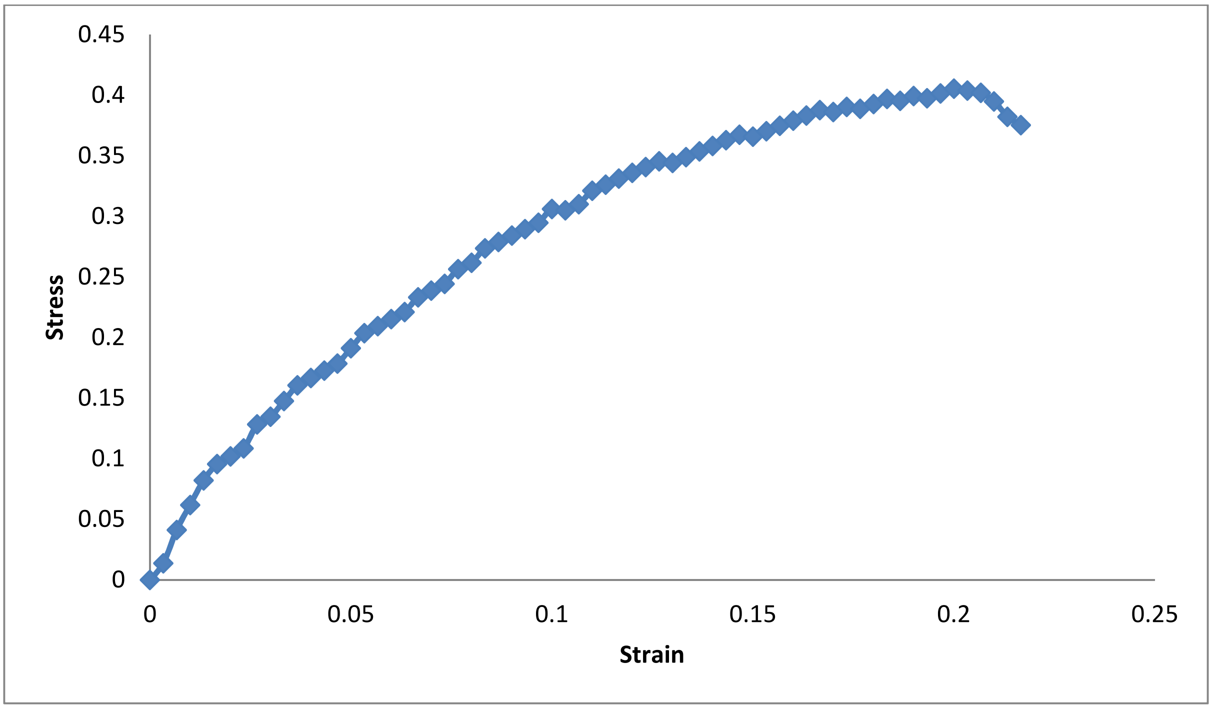


Figure 13 Stress strain curve

From the above graph it can be inferred that stress at failure is .405kg/cm^2

1.4 Soil with 2% fibre content

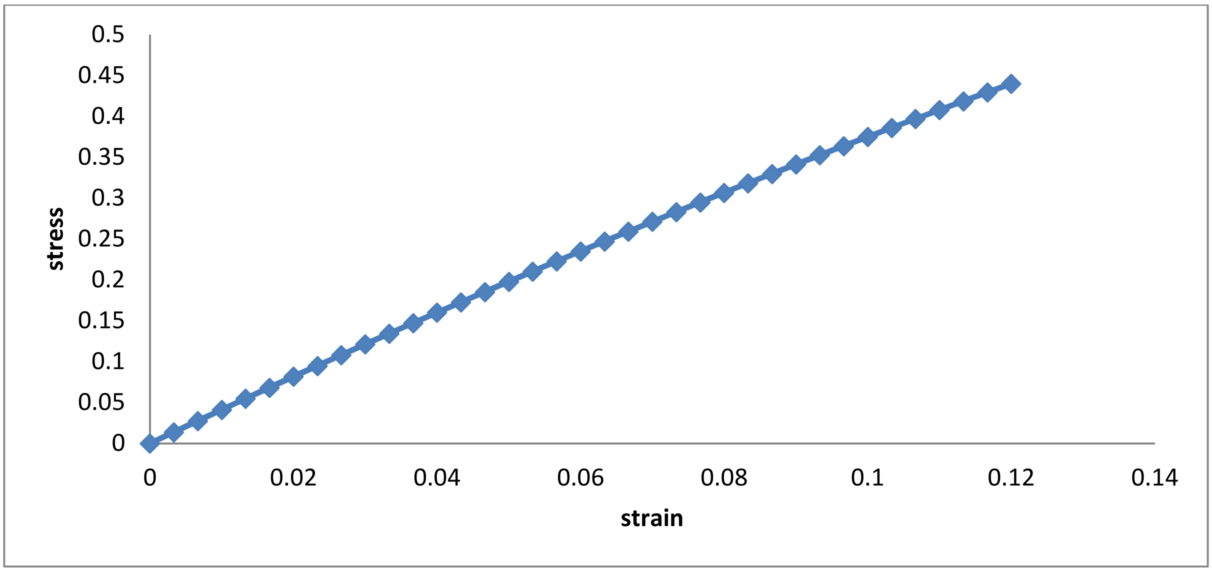


Figure 14 Stress strain curve

From the above graph it can be inferred that stress at failure is .44kg/cm^2

1.5 At 2.5% fibre content

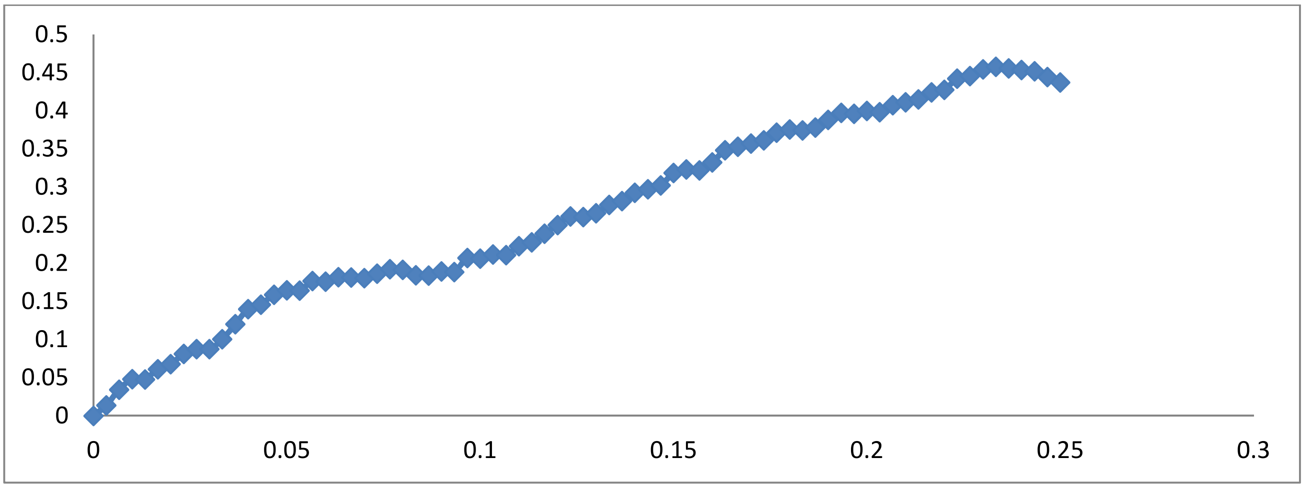


Figure 15 Stress Strain curve

From the above graph it can be inferred that stress at failure is -.497kg/cm^2

1.6 Soil with 3% fibre content

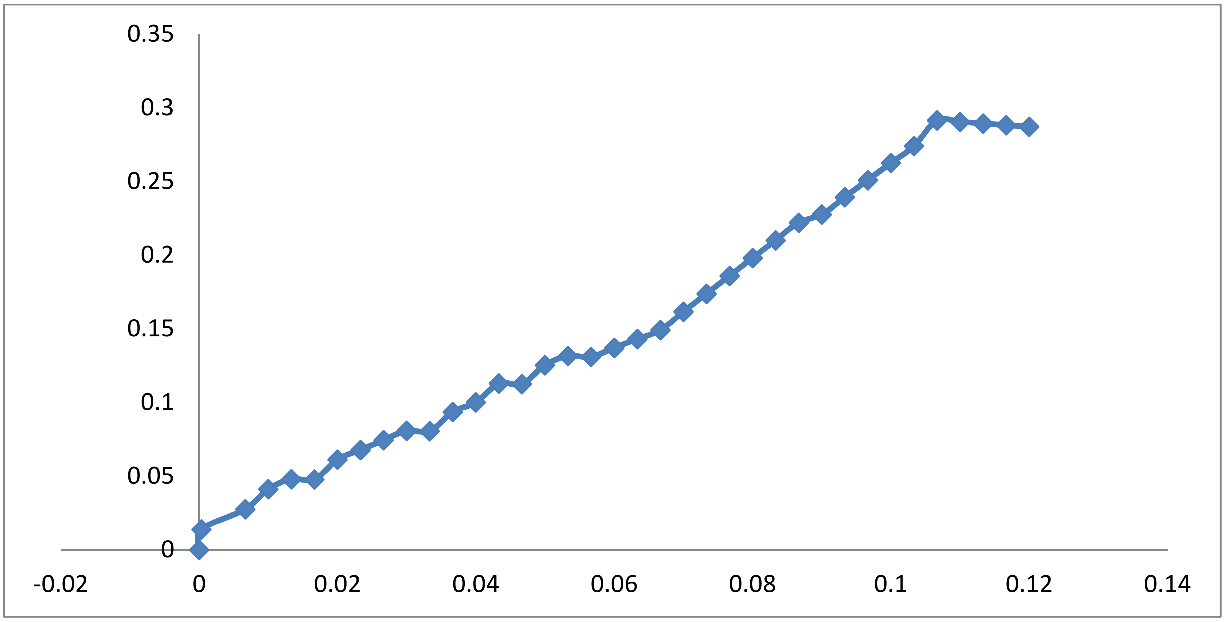


Figure 16 Stress Strain curve

From the above graph it can be inferred that stress at failure is -.29kg/cm^2

From the above graphs it can be concluded that shear strength of soil increases with increase in fibre content at 1.15kg/cm^2 normal load till 2.5%from.338kg/cm ^{2} to .497 kg/cm^2, after 2.5 % it is seen that shear strength further starts to decrease .This shows that 2.5% is optimum fibre content at given normal load

2. Normal load .95kg/cm^2

2.1 Soil without fibre content

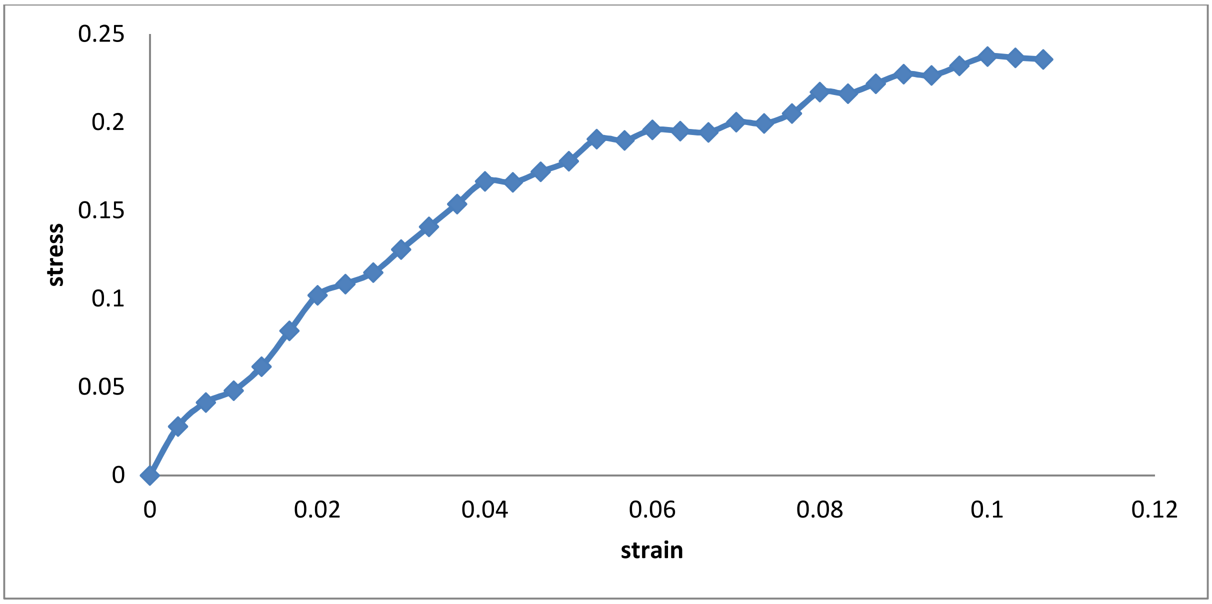


Figure 17 Stress Strain Curve

From the above graph it can be inferred that stress at failure is - .245kg/cm^2

2.2 Soil with 1% fibre content

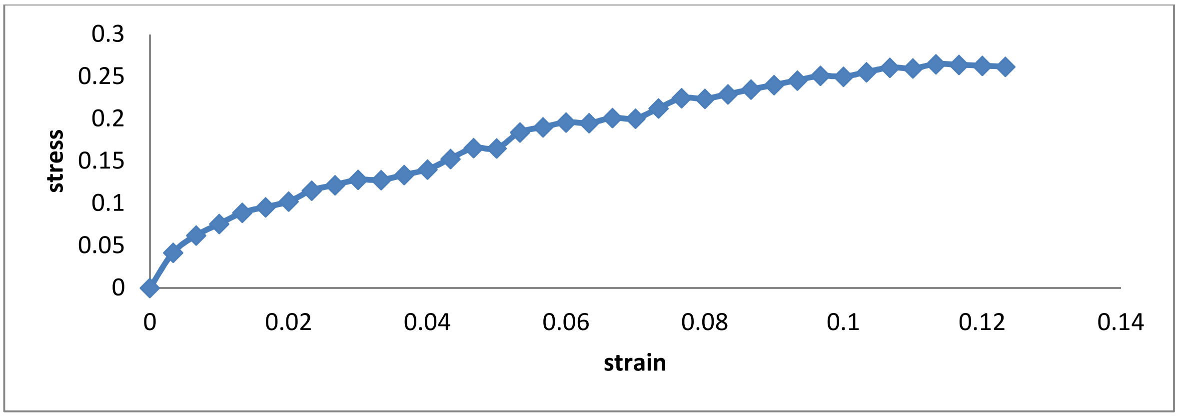


Figure 18 Stress strain curve

From the above graph it can be inferred that stress at failure is -.264kg/cm^2

2.3 Soil with 1.5% fibre content

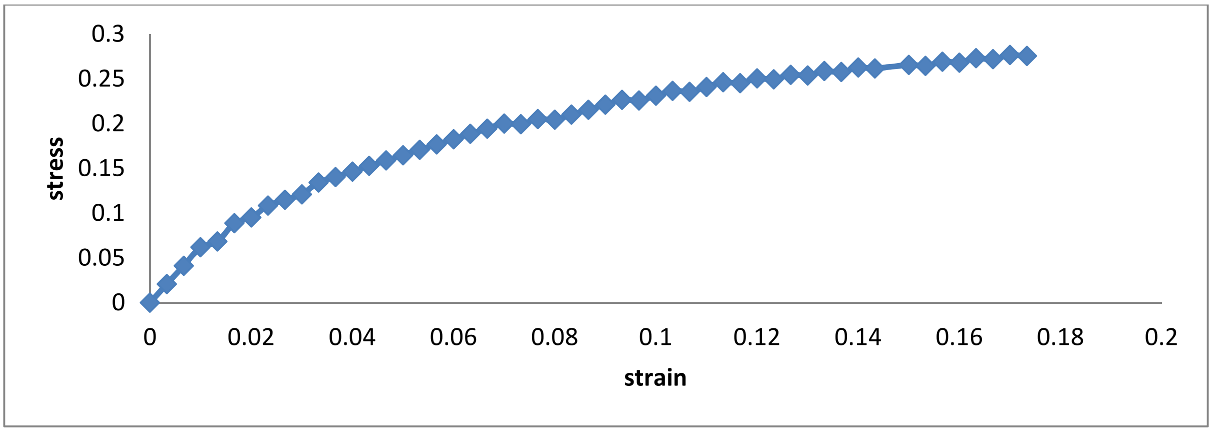


Figure 19 Stress strain curve

From the above graph it can be inferred that stress at failure is.273kg/cm^2

2.4 Soil with 2% fibre content

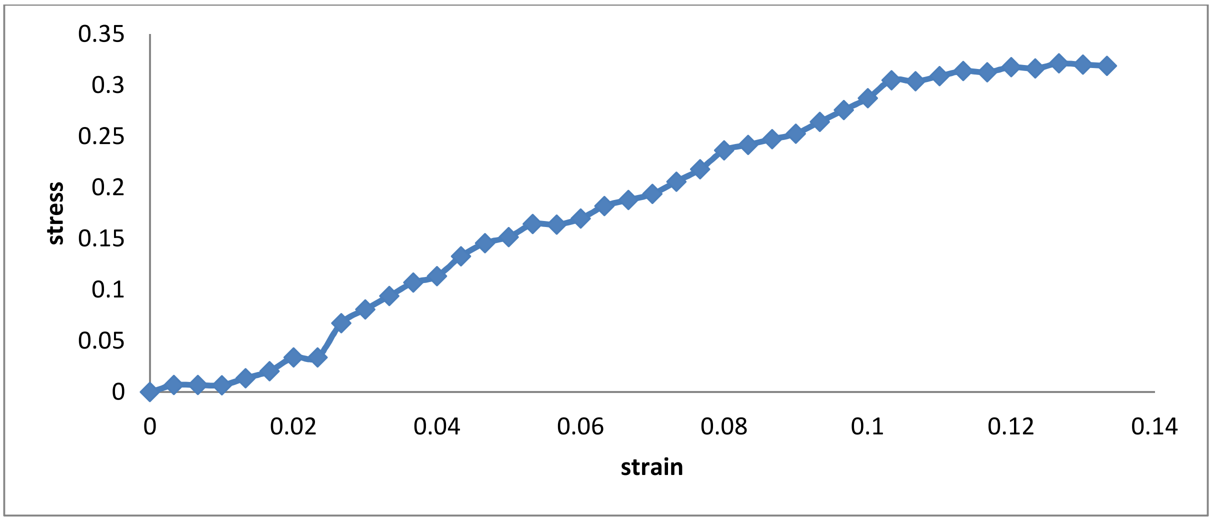


Figure 20 Stress strain curve

From the above graph it can be inferred that stress at failure is.- .321 kg/cm^2

2.5 Soil with 2.5% fibre content

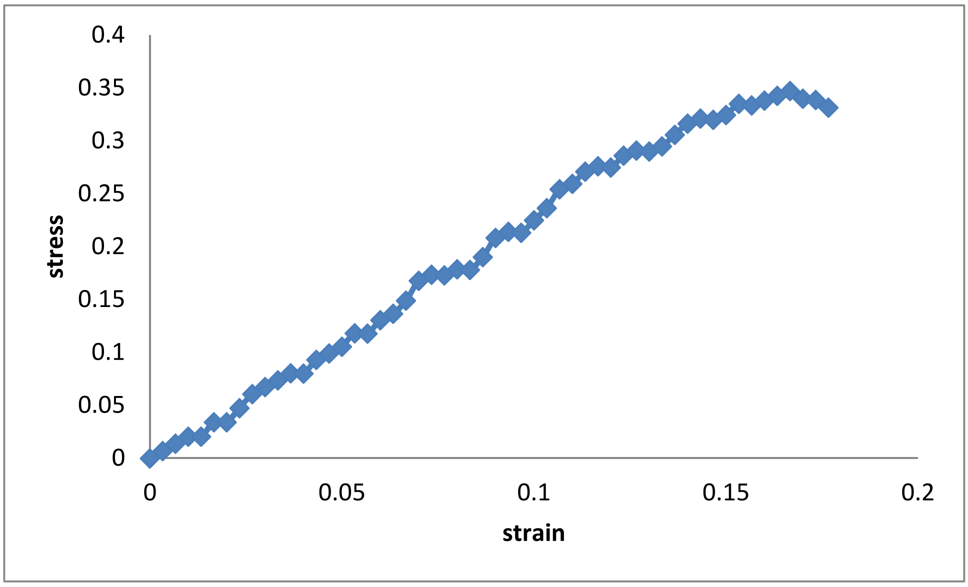
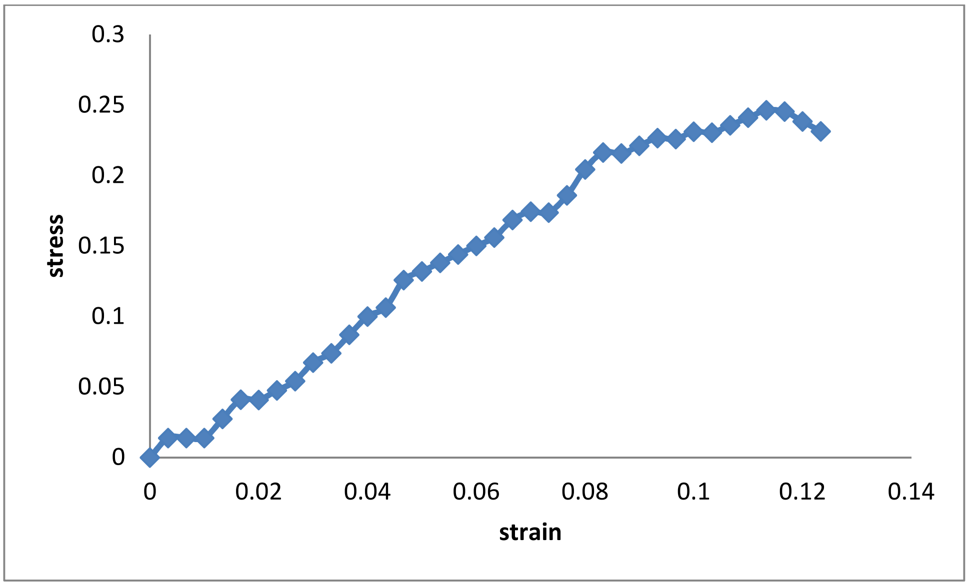


Figure 21 Stress Strain Curve

From the above graph it can be inferred that stress at failure is .163kg/cm^2

2.6Soil with 3% fibre content



From the above graph it can be inferred that stress at failure is-.246kg/cm^2

The above graphs show that the shear strength of soil increases to a value of .347kg/cm^2 from .264kg/cm^2 with increase in fibre content till 2.5% after that the shear strength starts to decrease . This shows that optimum fibre content at normal load .95kg/cm ^{2}is 2.5%.

3. Normal load -.55kg/cm^2

3.1 Soil with no fibre content

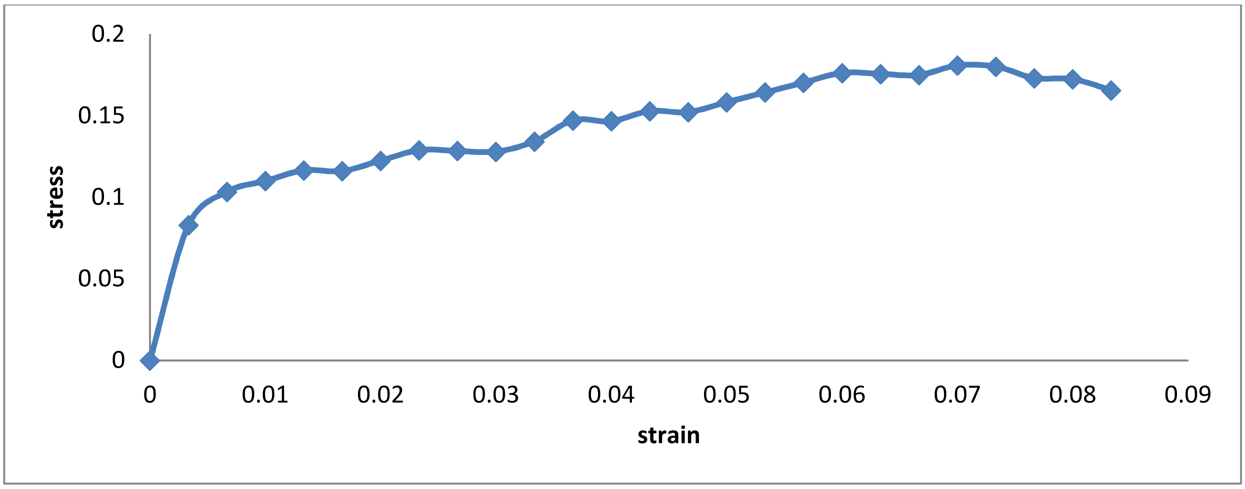


Figure 22 Stress strain curve

From the above graph it can be inferred that stress at failure is - .180kg/cm^2

3.2 Soil with 1% fibre content

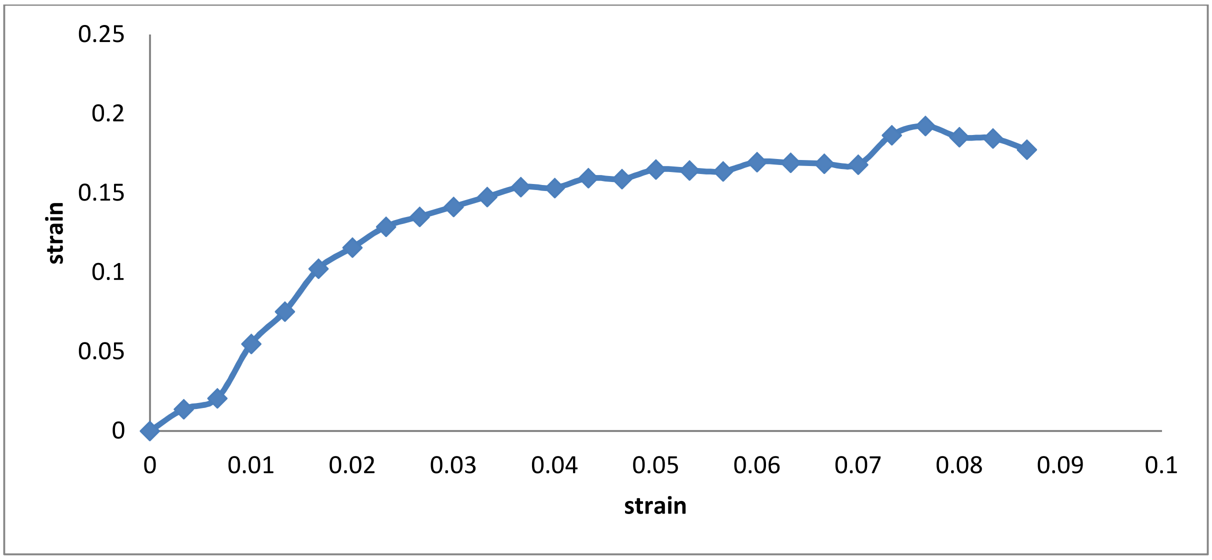


Figure 23 Stress strain curve

From the above graph it can be inferred that stress at failure is - .192 kg/cm^2

3.3 Soil with 1.5% fibre content

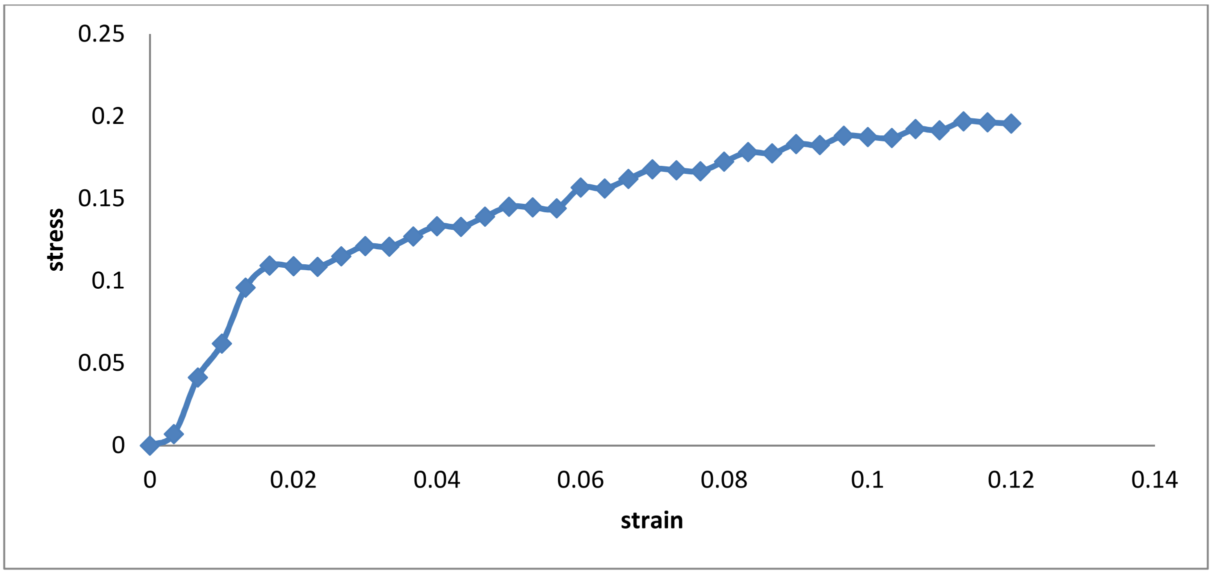


Figure 24 Stress strain curve

From the above graph it can be inferred that stress at failure is - .197kg/cm^2

3.4 Soil with 2% fibre content

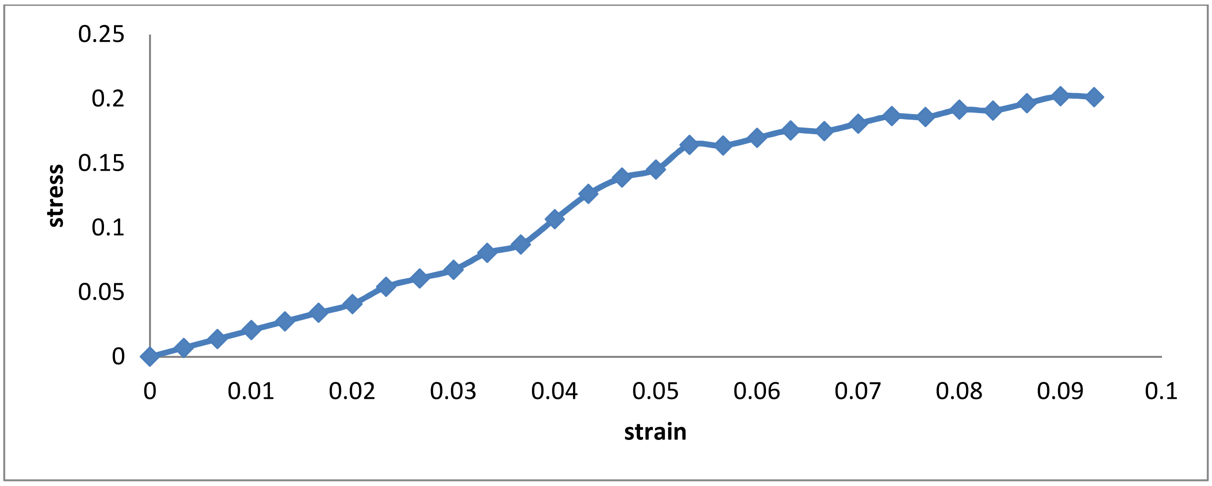


Figure 25 Stress strain curve

From the above graph it can be inferred that stress at failure is .202kg/cm^2

3.5 Soil with 2.5% fibre content

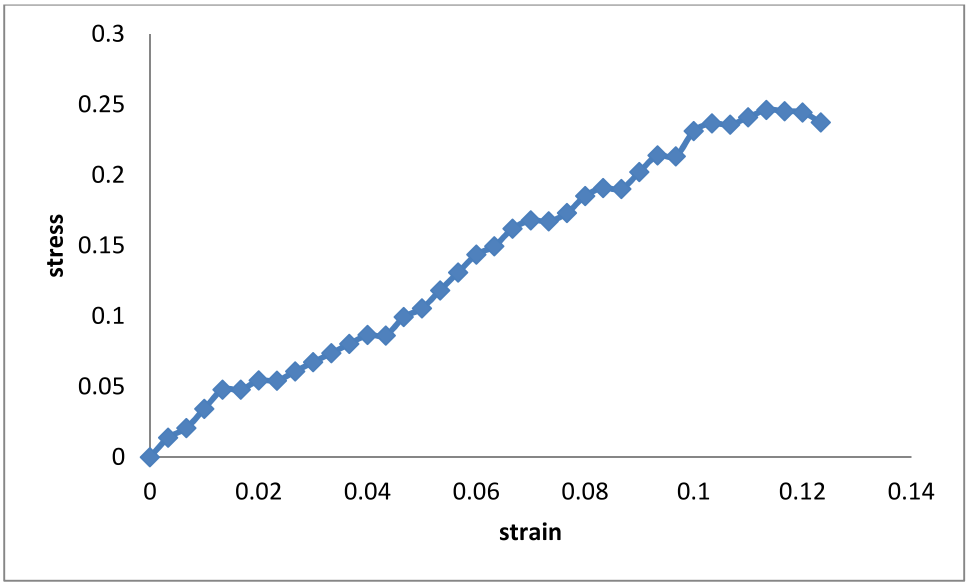


Figure 26 stress strain cuvre

From the above graph it can be inferred that stress at failure is -.246kg/cm^2

3.6Soil with 3% fibre content

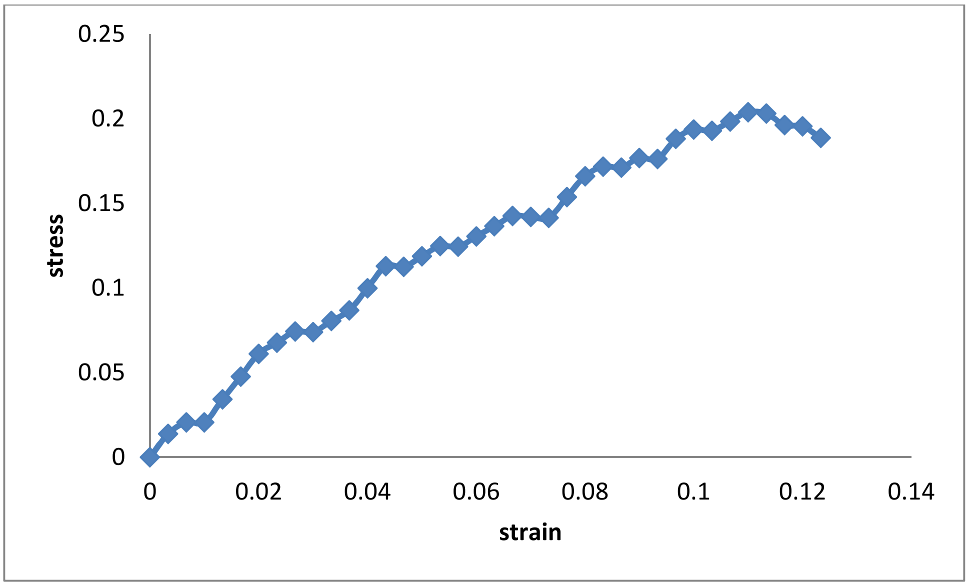


Figure 27 stress strain curve

From the above graph it can be inferred that stress at failure is .203kg/cm^2

At the given normal load of .55kg/cm^2 the value of shear strength increases from a value of 197kg/cm^2 to .246kg/cm^2 till fibre content of 2.5% .after that the strength starts to decrease as the fibre particles start replacing soil.

b) Coir fibre

1.Normal load -1.15kg/cm^2

1.1 Soil with fibre content 1%

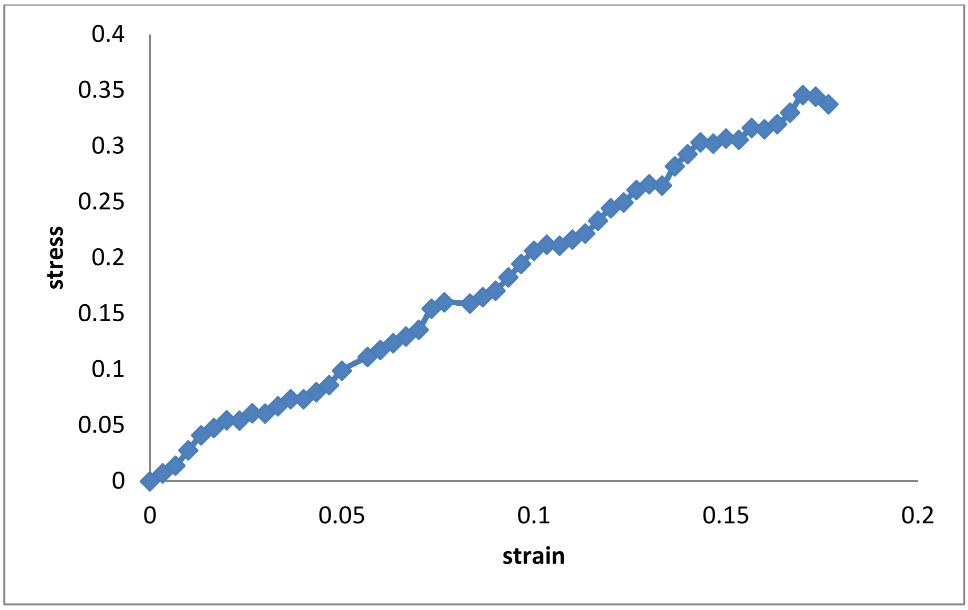


Figure 28 Stress Strain Curve

From the above graph it can be inferred that stress at failure is .345kg/cm^2

1.2 Soil with fibre content 2%

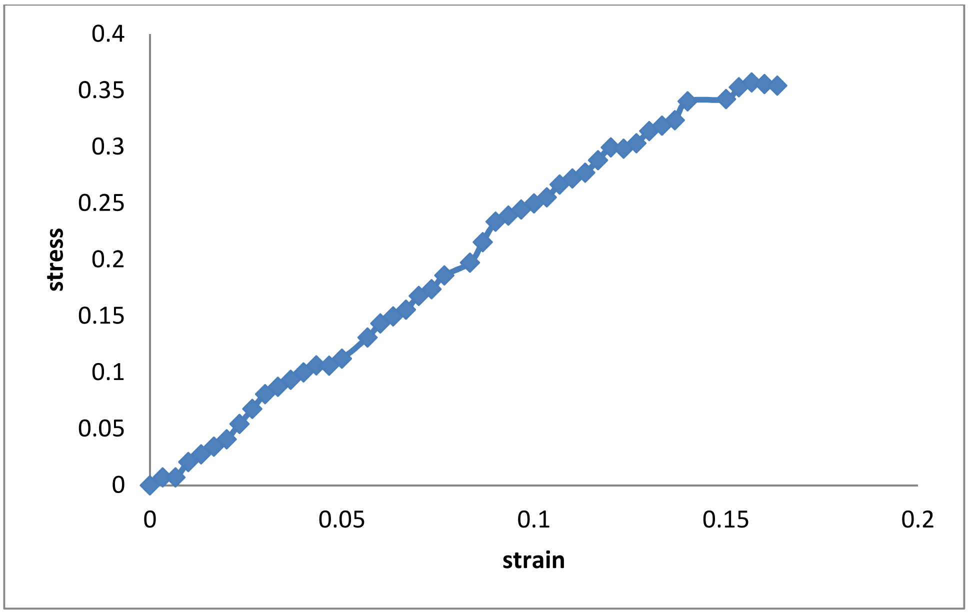


Figure 29 Stress Strain curve

From the above graph it can be inferred that stress at failure is .357kg/cm^2

1.3 Soil with fibre content 3%

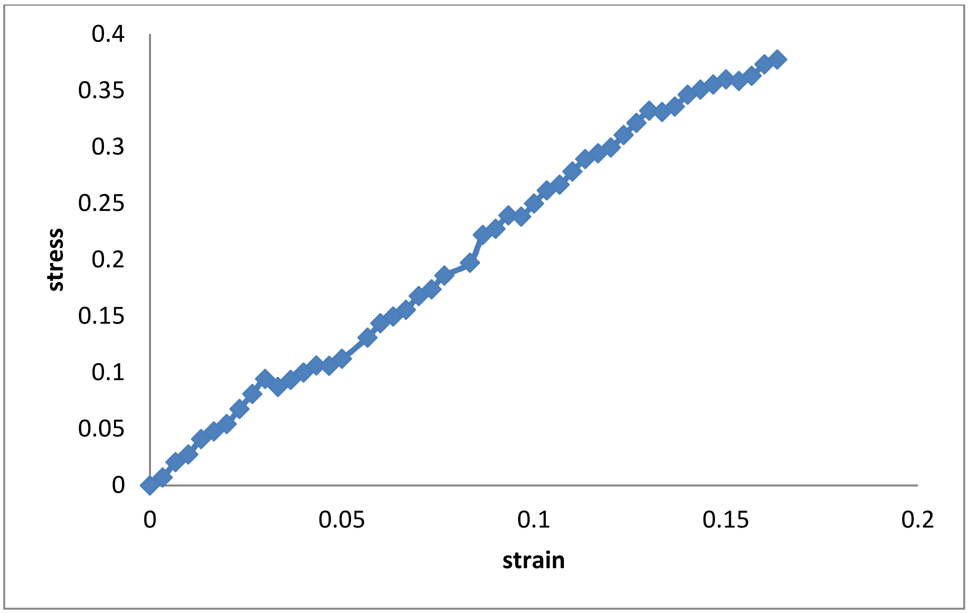


Figure 30 Stress Strain curve

From the above graph it can be inferred that stress at failure is .377kg/cm^2

1.4 Soil withfibre content 4%

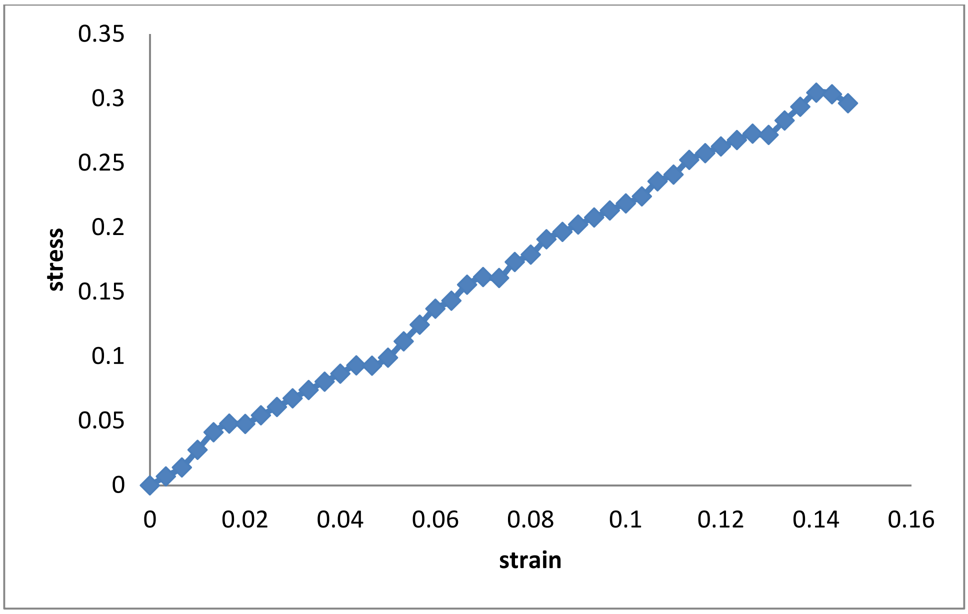


Figure 31 Stress Strain curve

From the above graph it can be inferred that stress at failure is .33kg/cm^2

By the use of coconut fibre at normal load 1.15kg/cm^2 the shear strength of soil increases from .338kg/cm^2 to .377kg/cm^2 at 3% fibre content after that shear strength starts to decrease.

2. Normal load -.95kg/cm^2

2.1 Soil with 1% fibre content

Stress at failure-.259kg/cm^2

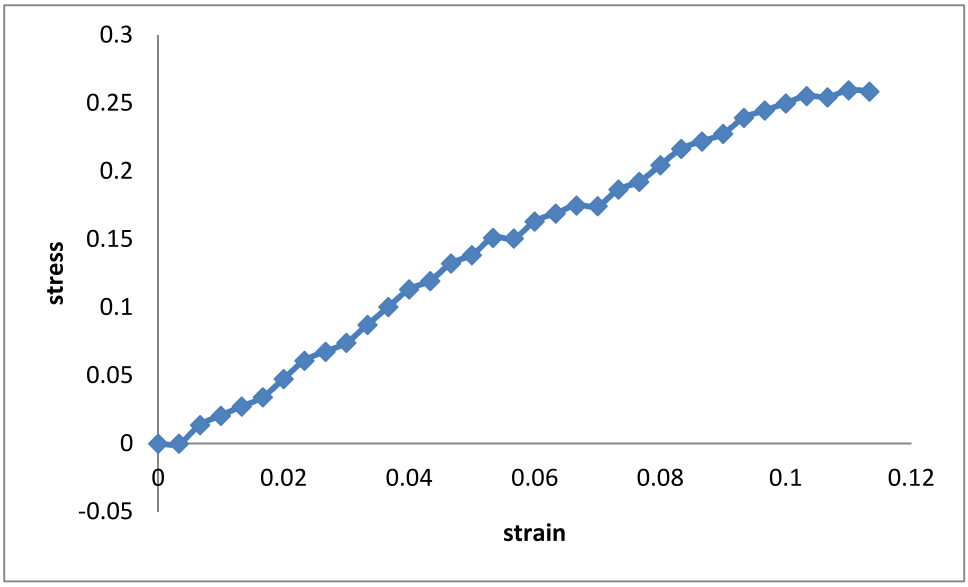


Figure 32 Stress Strain curve

From the above graph it can be inferred that stress at failure is .259kg/cm^2

2.2 Soil with 2% fibre content

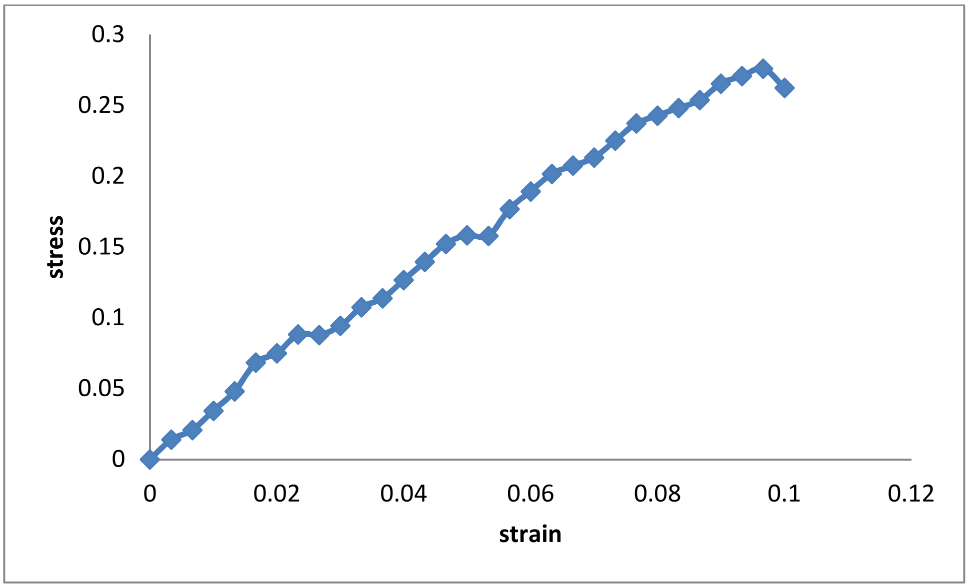


Figure 33 Stress Strain curve

From the above graph it can be inferred that stress at failure is .276 kg/cm^2

2.3 Soil with 3% fibre content

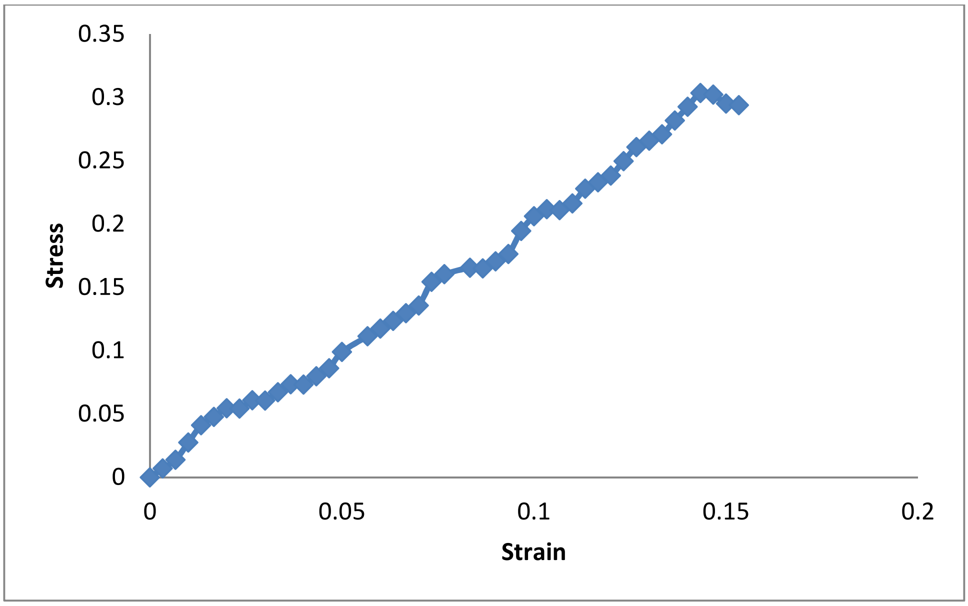


Figure 34 Stress Strain curve

From the above graph it can be inferred that stress at failure is .302kg/cm^2

2.4 Soil with 4% fibre content

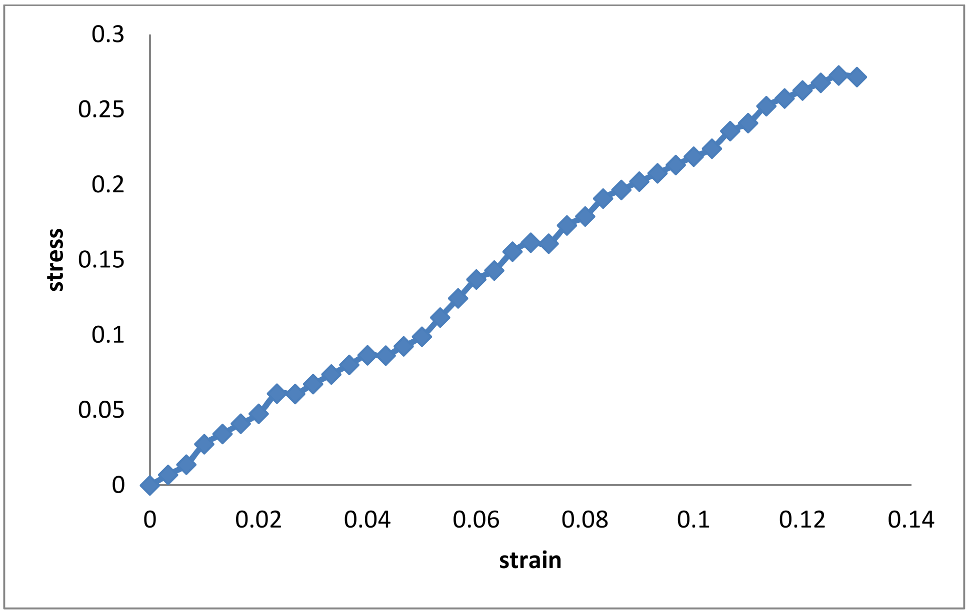


Figure 35 Stress Strain curve

From the above graph it can be inferred that stress at failure is .272 kg/cm^2

At normal load of .95kg/cm^2 the value of shear strength increases to .377kg/cm^2 at 3% fibre content from .264 kg/cm^2 at 0% fibre content. From 4% onwards the value starts coming down hence showing that 3% optimum fibre content for given normal load.

3. Normal load -.55kg/cm^2

3.1 Soil with 1% fibre content

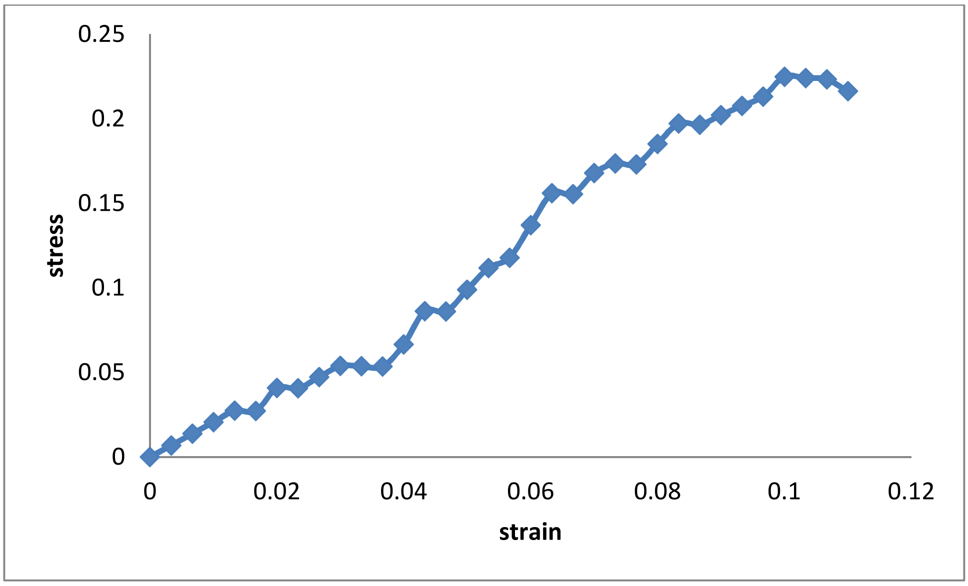


Figure 36 Stress Strain curve

From the above graph it can be inferred that stress at failure is .225kg/cm^2

3.2Soil with 2% fibre content

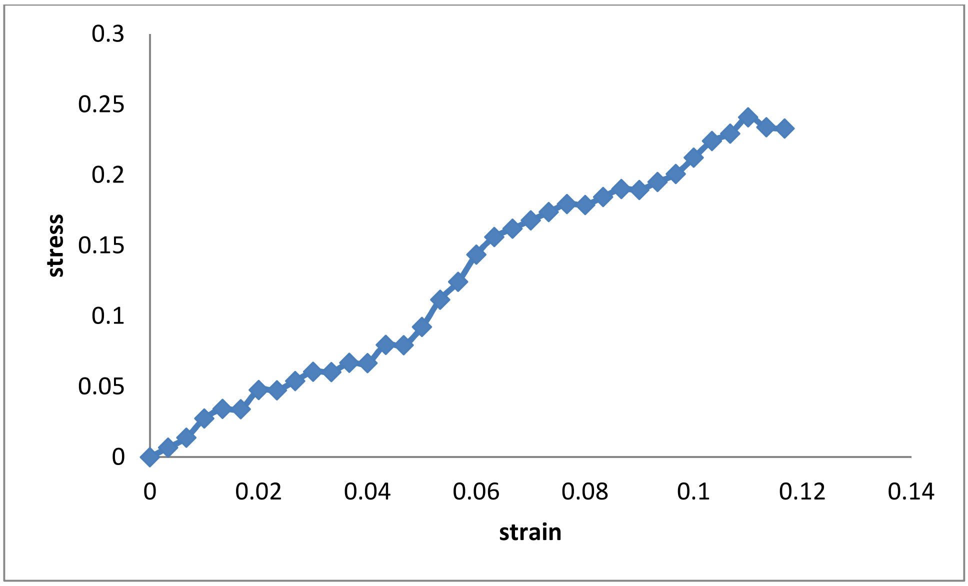


Figure 37 Stress Strain curve

From the above graph it can be inferred that stress at failure is .241kg/cm^2

3.3 Soil with 3% fibre content

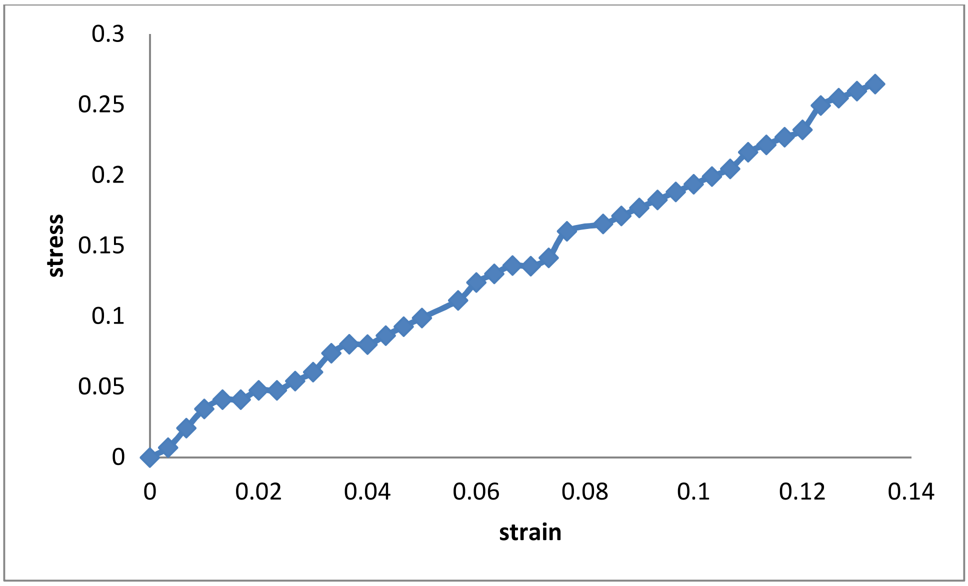


Figure 38 Stress Strain curve

From the above graph it can be inferred that stress at failure is .246kg/cm^2

3.4Soil with 4% fibre content

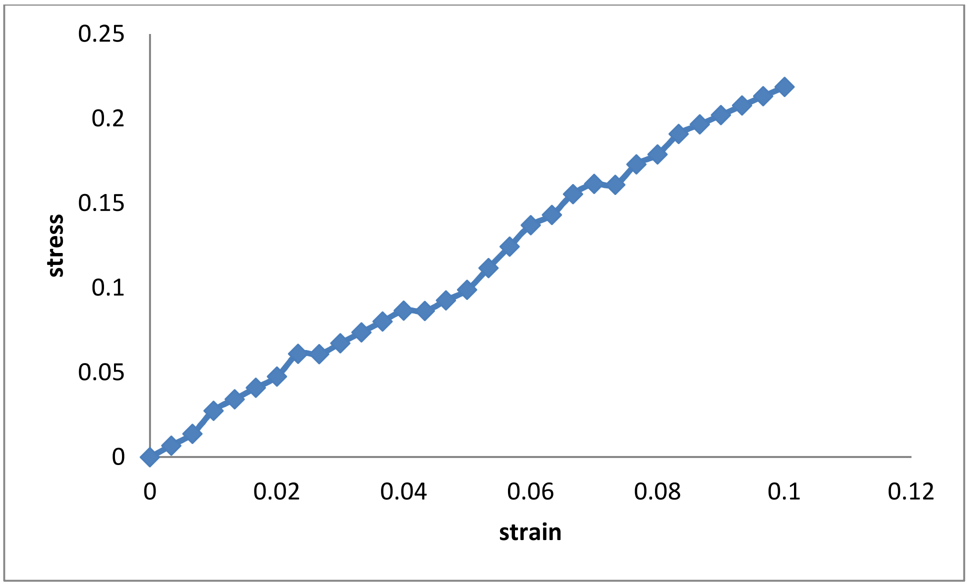


Figure 39 Stress Strain curve

From the above graph it can be inferred that stress at failure is .218kg/cm^2

At normal load of .55kg/cm^2 the shear strength of soil increases from .180kg/cm^2 to .264kg/cm^2 till 3% fibre content. After that shear strength starts to decrease .This shows that optimum fibre content is 3%.

4.7 Variation between normal stress and shear strength at various fibre contents:-

a) Polypropylene fibre

1. At 0% fibre content

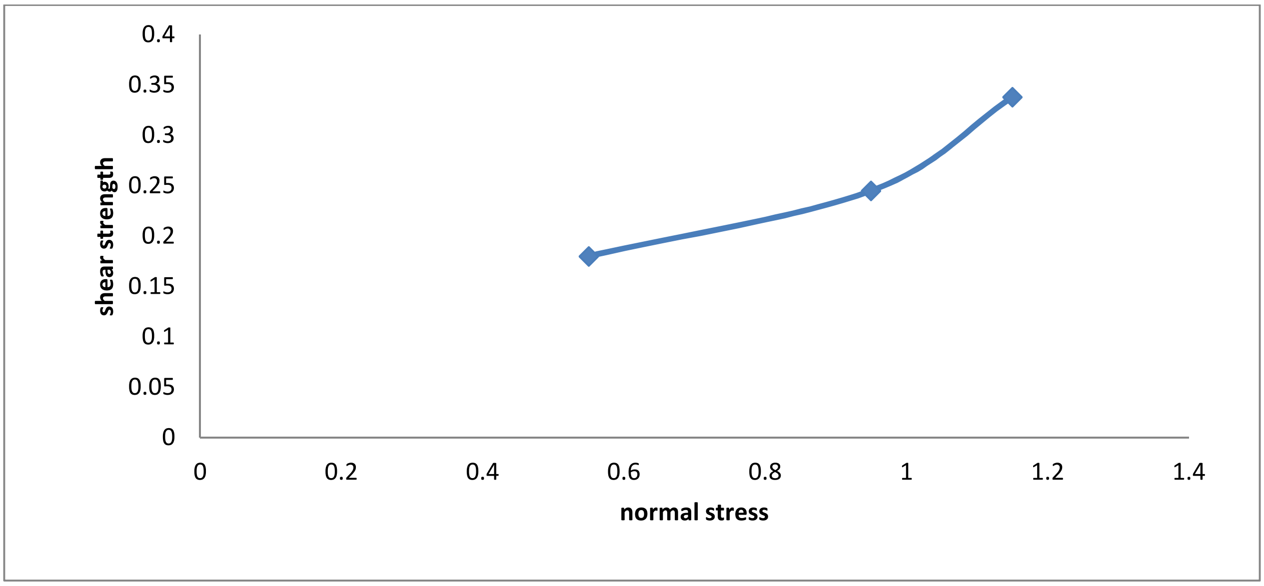


Figure 40 Variation of shear stress with normal stress at given fibre content

2.At 1% fibre content

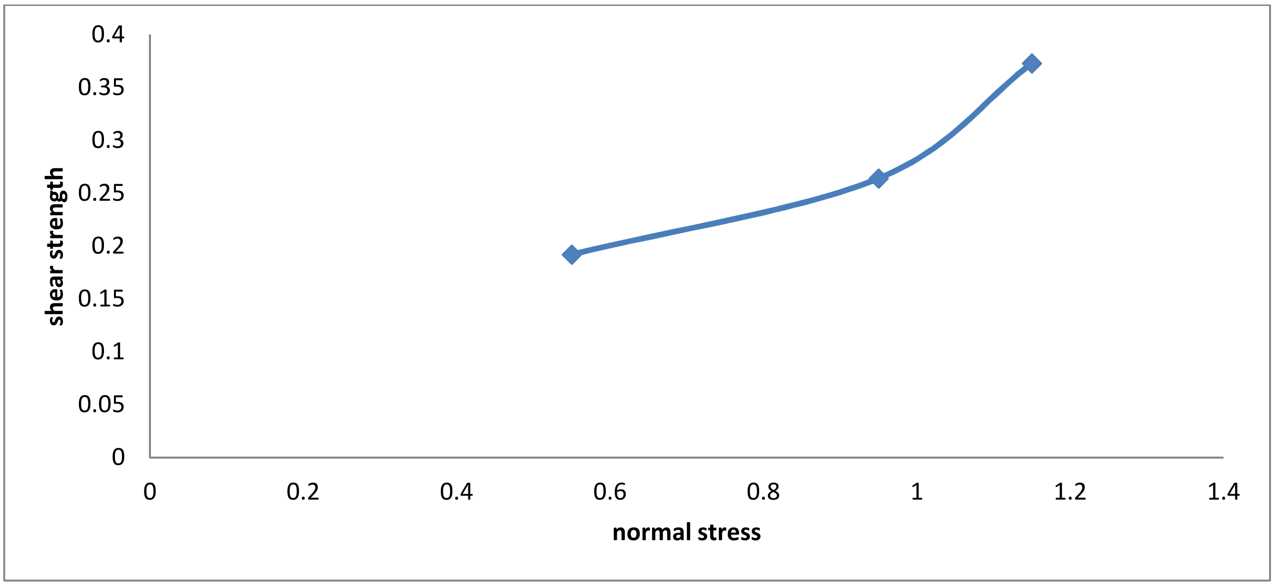


Figure 41 Variation of shear stress with normal stress at given fibre content

3. At 1.5% fibre content

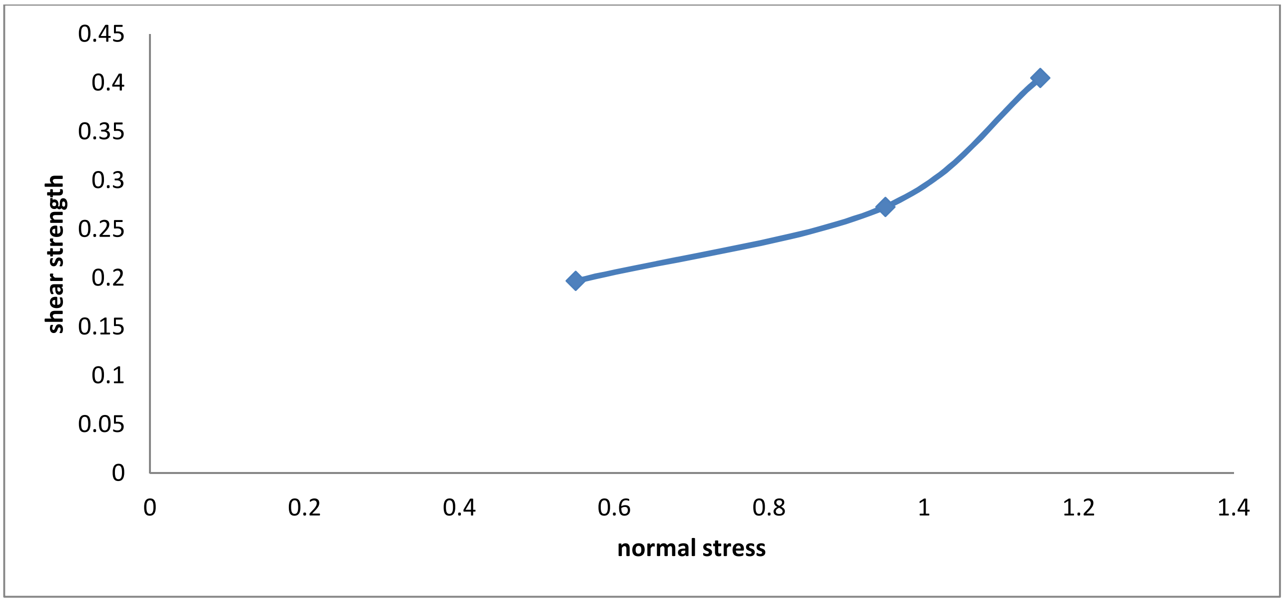


Figure 42 Variation of shear stress with normal stress at given fibre content

4. At 2% fibre content-

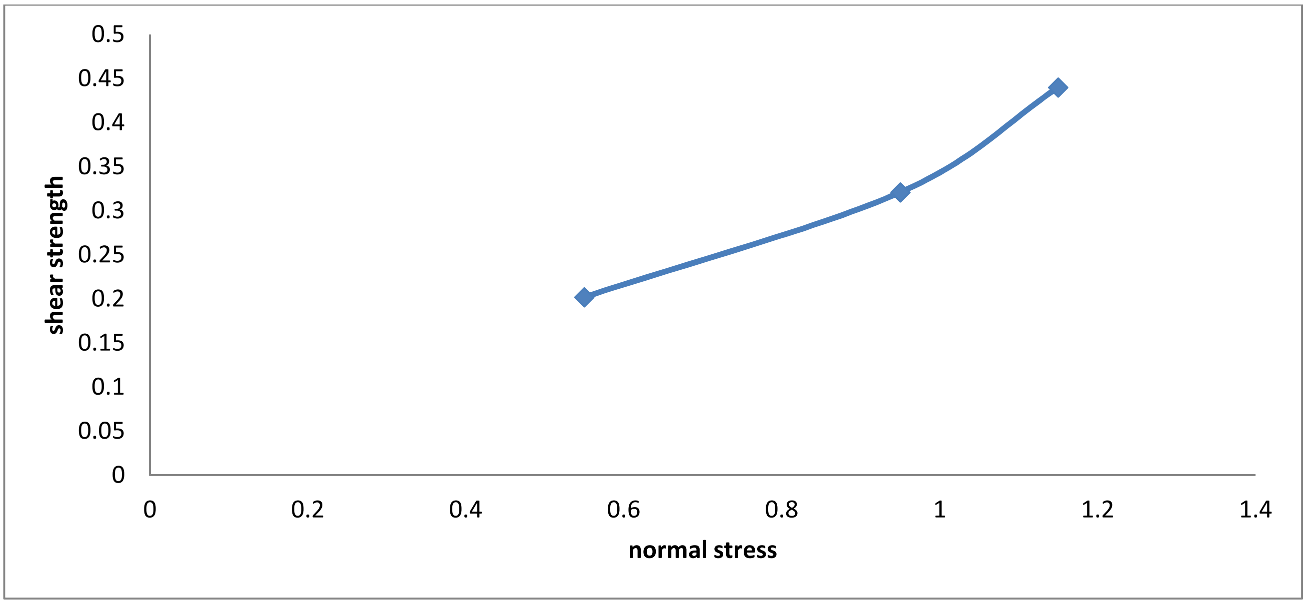


Figure 43 Variation of shear stress with normal stress at given fibre content

5. At 2.5% fibre content

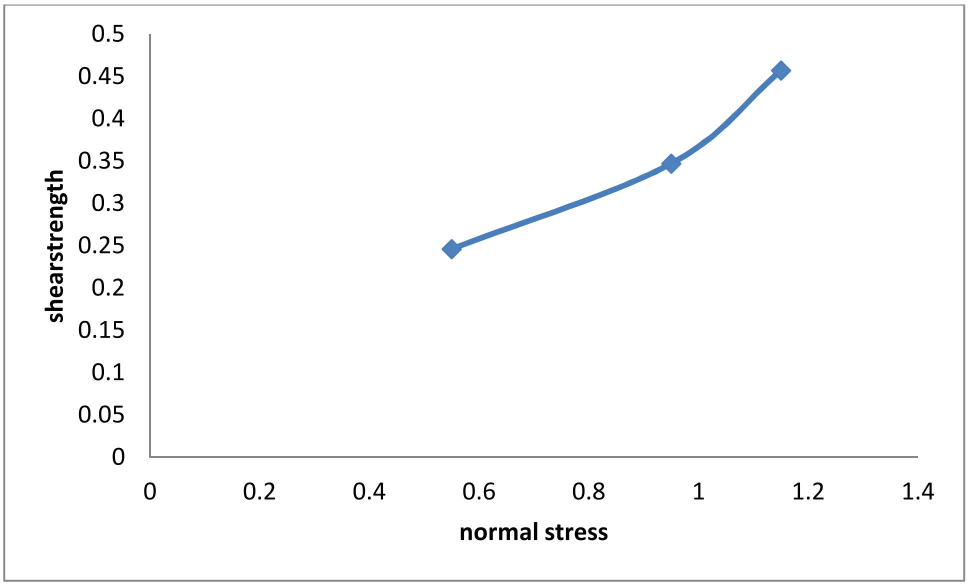


Figure 44Variation of shear stress with normal stress at given fibre content

6. At 3% fibre content

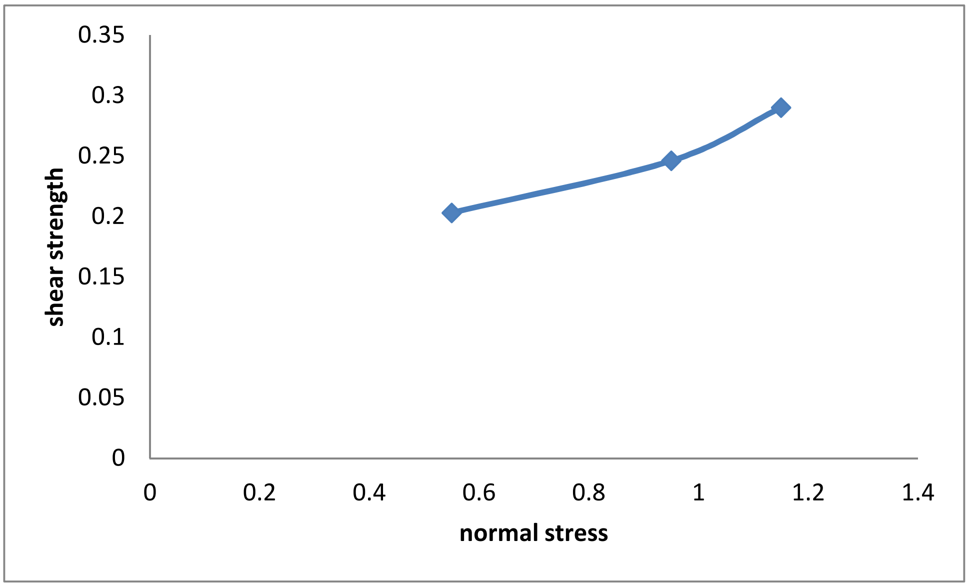


Figure 45Variation of shear stress with normal stress at given fibre content

b) Coir fibre

1. At 1% fibre content

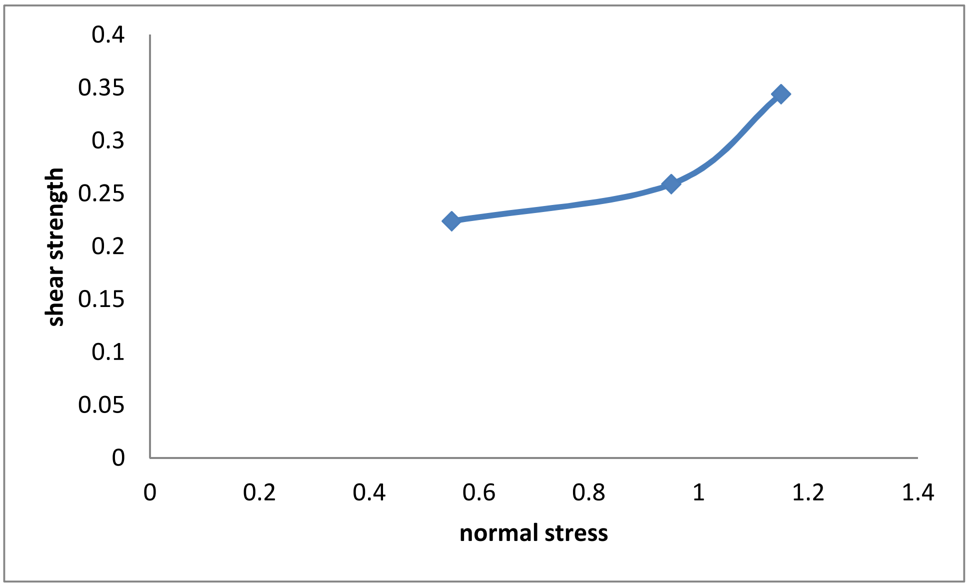


Figure 46Variation of shear stress with normal stress at given fibre content

2. At 2% fibre content

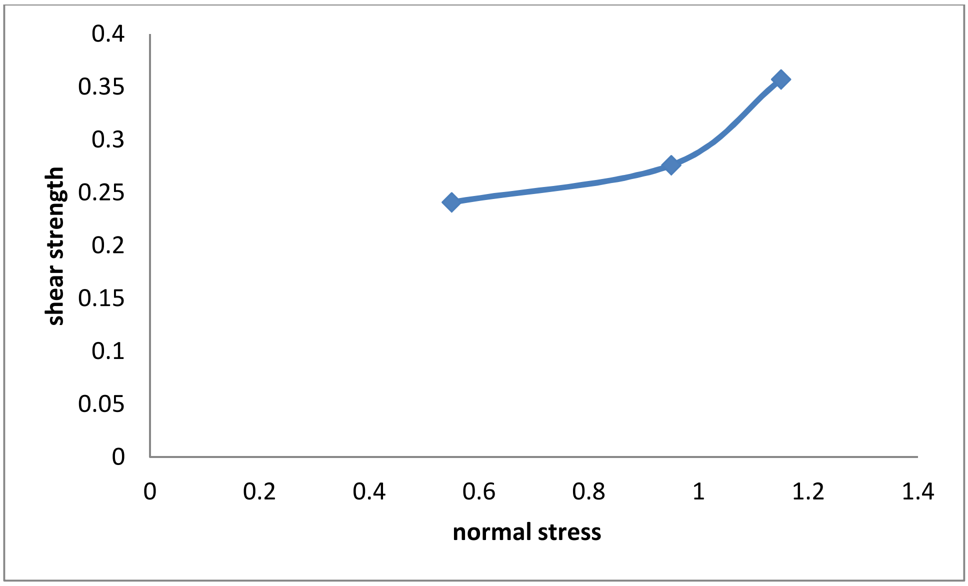


Figure 47Variation of shear stress with normal stress at given fibre content

3. At 3% fibre content

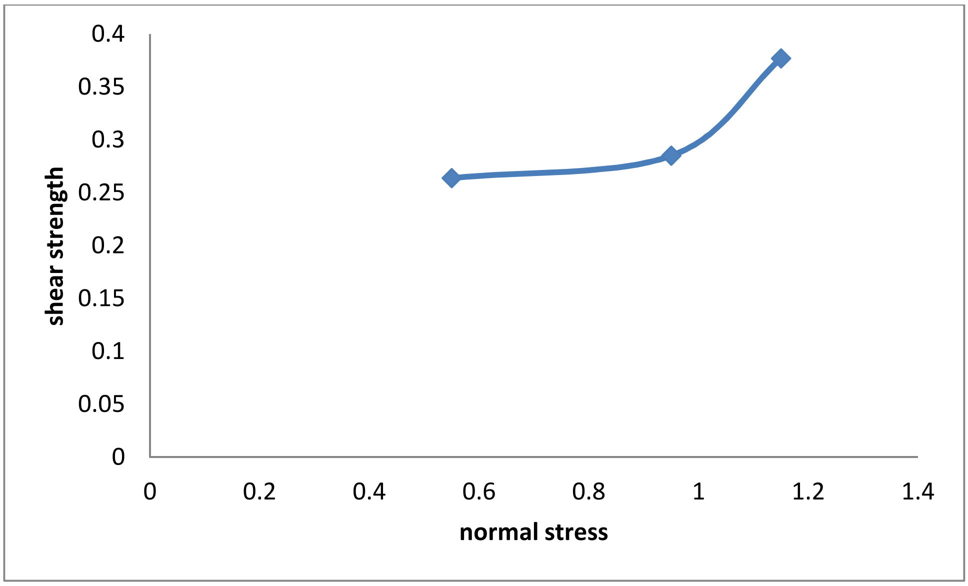


Figure 48Variation of shear stress with normal stress at given fibre content

4. At 4% fibre content

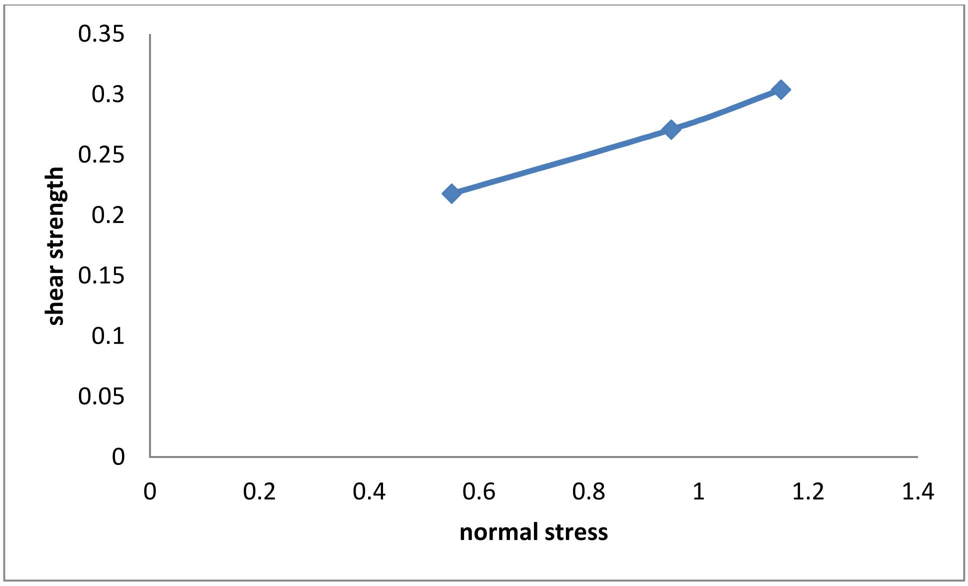


Figure 49Variation of shear stress with normal stress at given fibre content

4.8. Variation of shear strength with fibre content at particular normal load:-

a) Polypropylene fibre

1. At normal load .55kg/cm^2 :-

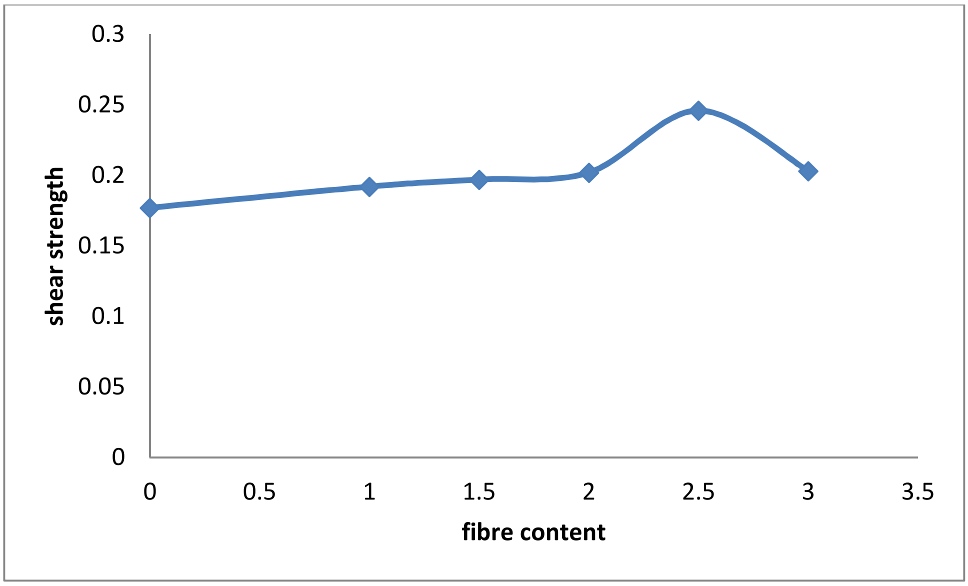


Figure 50.optimum fibre content

Above figure shows variation of shear strength with fibre content at normal load .55kg/cm^2

2. At Normal load .95 kg/cm^2

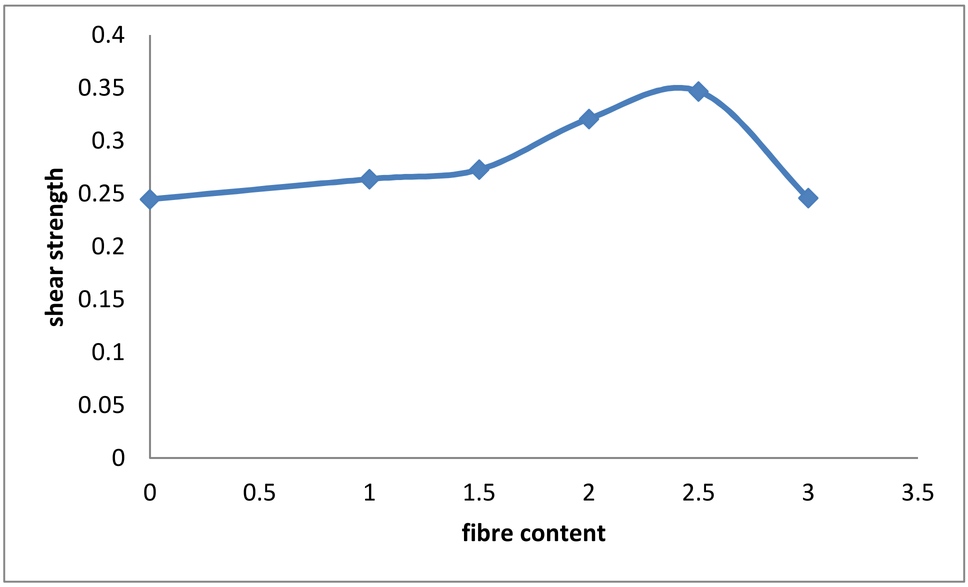


Figure 51 optimum fibre content

Above figure shows variation of shear strength with fibre content at normal load.95kg/cm^2

3. At normal load 1.15kg/cm^2

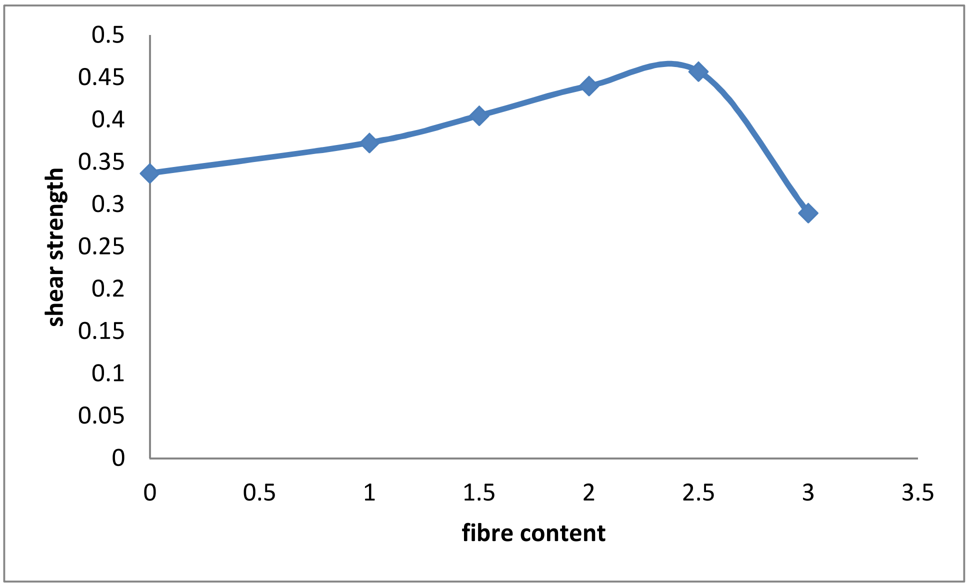


Figure 52 optimum fibre content

Above figure shows variation of shear strength with fibre content at normal load1.15kg/cm^2

From the above graphs it can be concluded that optimum fibre content for polypropylene is 2.5% at any normal load , above that shear strength starts to decrease as fibre starts replacing the soil .

b) Coir fibre

1.At normal load .55kg/cm^2

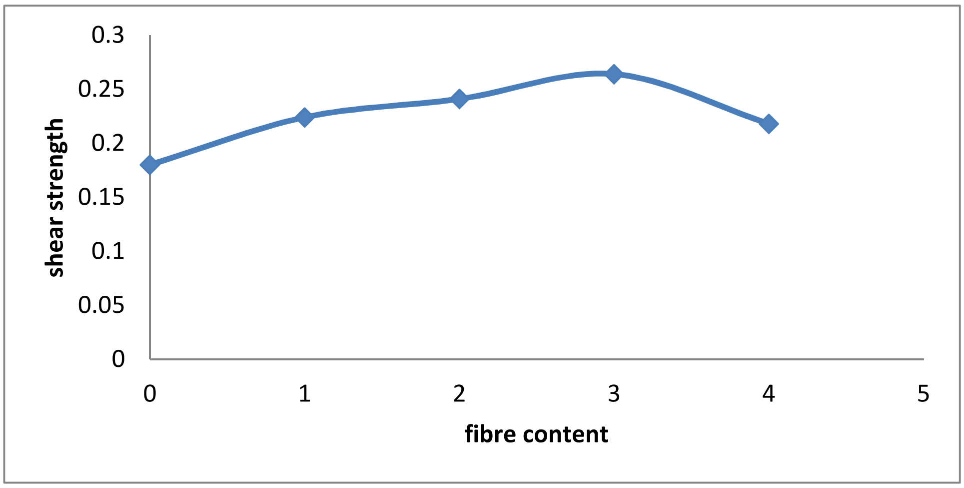


Figure 53 optimum fibre content

2.At normal load .95kg/cm^2

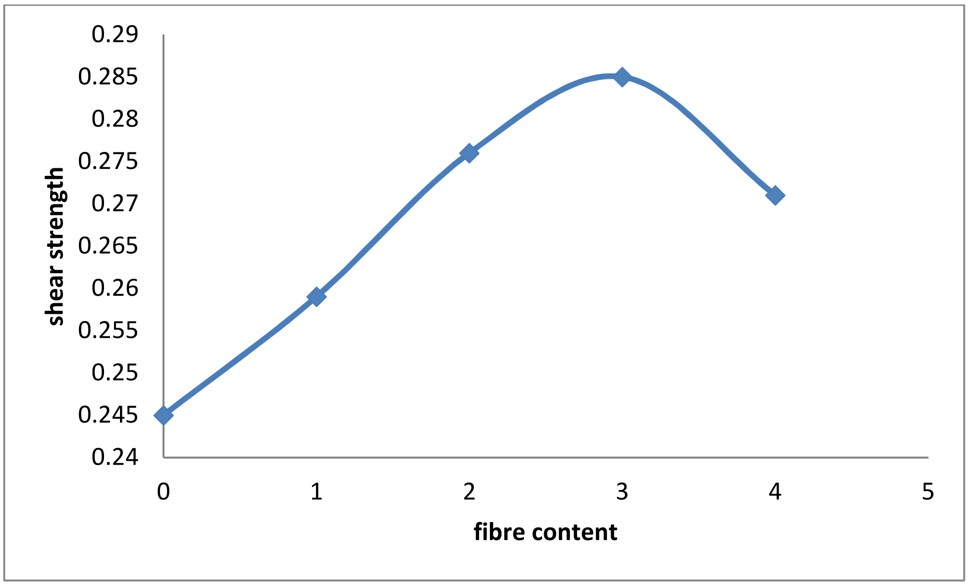


Figure 54 optimum fibre content\

Above figure shows variation of shear strength with fibre content at normal load .95kg/cm^2

3. At normal load 1.15kg/cm^2

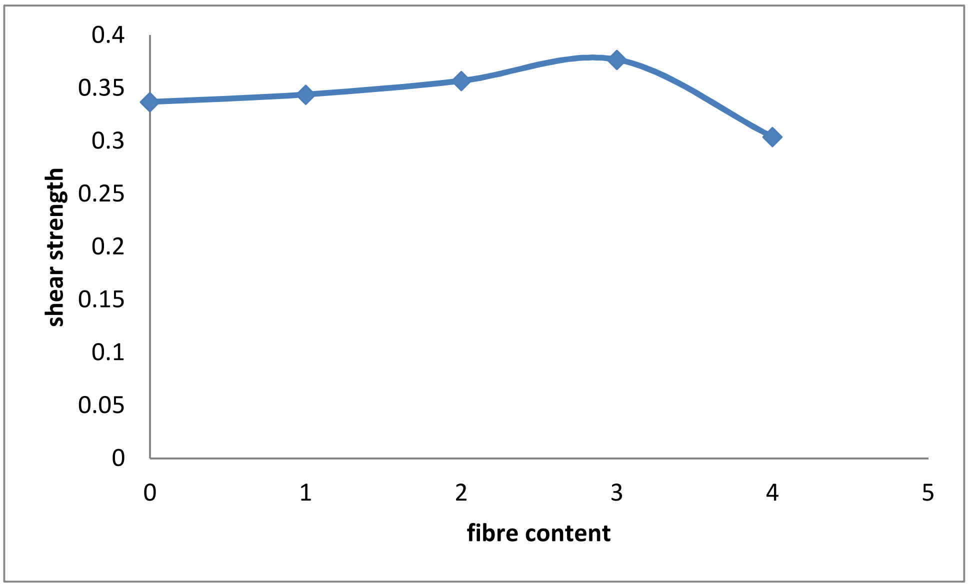


Figure 55 optimum fibre content

Above figure shows variation of shear strength with fibre content at normal load1.15kg/cm^2

From the above graphs it can be concluded that optimum fibre content of coir fibre as a soil reinforcement is 3%.If quantity of fibre is further increased the shear strength stars to decrease.

4.5Discussion

Shear stress at failure for coir fibre

Normal load on soil = 1.15 kg/cm^2		
Fibre content	Stress at failure(kg/cm^2)	%age increase
0% fibre content	0.338	
1% fibre content	0.345	2.07
2% fibre content	0.357	5.62
3 % fibre content	0.377	11.53
4% fibre content	0.33	-2.36
Nomral load .95kg/cm^2		
0% fibre content	0.245	
1% fibre content	0.259	5.71
2% fibre content	0.276	12.65
3 % fibre content	0.302	23.26
4% fibre content	0.272	11.02
Normal load = .55 kg/cm^2		
0% fibre content	0.18	
1% fibre content	0.225	25
2% fibre content	0.241	33.88
3 % fibre content	0.264	46.67
4% fibre content	0.218	21.11

Table 7 Shear stress at failure for coir fibre

The above table shows the percentage increase in shear strength of soil using coir fibre. At optimum fibre content of 3% the increase is maximum. Also the percentage increase is more at lower normal load that higher normal load. The percentage increase in shear strength of soil starts to decrease or becomes negative after optimum fibre content.

Shear stress at failure for polypropylene fibre

Normal load 1.15 kg/cm^2		
Fibre content	Shear stress at failure(kg\cm^2)	%age increase
0% fibre content	0.338	
1% fibre content	0.373	10.35
1.5% fibre content	0.405	19.82
2 % fibre content	0.44	30.17
2.5% fibre content	0.497	47.04
3% fibre content	0.29	-14.20
Normal load .95kg/cm^2		
0% fibre content	0.245	
1% fibre content	0.264	7.75
1.5% fibre content	0.273	11.42
2 % fibre content	0.321	31.02
2.5% fibre content	0.352	43.67
3% fibre content	0.246	0.40
Normal load .55kg/cm^2		
0% fibre content	0.18	
1% fibre content	0.192	6.67
1.5% fibre content	0.197	9.44
2 % fibre content	0.202	12.22
2.5% fibre content	0.246	36.67
3% fibre content	0.203	12.77

Table 8 Shear stress at failure for polypropylene fibre

The above table shows percentage increase in shear strength of soil using polypropylene fibre. The percentage increase is maximum for fibre content of 2.5%,after that percentage increase starts to decrease or even become negative. By use of polypropylene fibre increase is more for higher normal load .

Angle of internal friction for coir fibre:-

Normal load = 1.15 kg/cm^2		
Fibre content	Angle of internal friction	%age increase
0% fibre content	16.37	
1% fibre content	16.69	1.91
2% fibre content	17.24	3.19
3 % fibre content	18.15	5.01
4% fibre content	14.20	-13.55
Normal load = .95 kg/cm^2		
0% fibre content	14.44	
1% fibre content	15.25	5.31
2% fibre content	16.19	12.80
3 % fibre content	17.68	22.42
4% fibre content	15.90	10.19
Normal load = .55 kg/cm^2		
0% fibre content	18.12	
1% fibre content	22.15	18.19
2% fibre content	23.32	28.26
3 % fibre content	25.64	39.29
4% fibre content	21.62	19.3

Table 9 Angle of internal friction for coir fibre

The above table shows the percentage increase in angle of internal friction of soil using coir fibre. At optimum fibre content of 3% the increase is maximum. Also the percentage increase is more at lower normal load that higher normal load. The percentage increase in angle of internal friction of soil starts to decrease or becomes negative after optimum fibre content

Calculation of angle of internal friction for polypropylene fibre :

Normal load 1.15 kg/cm^2		
Fibre content	Angle of internal friction	%age increase
0% fibre content	16.37	
1% fibre content	17.97	9.73
1.5% fibre content	19.40	18.57
2 % fibre content	20.93	18.51
2.5% fibre content	23.37	27.8
3% fibre content	15.97	-2.44
Normal load .95kg/cm^2		
0% fibre content	14.46	
1% fibre content	15.53	7.3
1.5% fibre content	16.03	10.8
2 % fibre content	18.66	29.0
2.5% fibre content	20.06	38.72
3% fibre content	15.53	7.3
Normal load .55kg/cm^2		
0% fibre content	18.12	
1% fibre content	19.24	6.12
1.5% fibre content	19.70	8.33
2 % fibre content	20.16	11.28
2.5% fibre content	24.12	33.11
3% fibre content	20.24	-11.6

Table 10 Angle of internal friction for polypropylene fibre

The above table shows that percentage increase in angle of internal friction of soil using polypropylene fibre. The percentage increase is maximum for fibre content of 2.5%.After that percentage increase starts to decrease or even become negative. By use of polypropylene fibre increase is more for higher normal load .

CHAPTER-5

Conclusion

1. After conducting the sieve analysis it was found that soil in our campus is sandy soil. Since the soil was well graded gravel ,sample from waknaghat was taken to carry out the study. Since the sample was well graded sand no liquid limit and plastic limit were performed .
2. From light proctor test it was observed that optimum moisture content for soil was 16% .
3. By direct shear test at various fibre contents it was found that shear strength of the soil increased by use of fibre till a certain optimum value(2.5% for polypropylene and 3% for coir) and after that starts to decrease .The reason for decrease was that after certain fibre content the fibre started to replace the soil particles.
4. Coir is a biodegradable substance and polypropylene in non biodegradable. Coir is more eco-friendly but in long run it may get degraded and soil may lose its shear strength. So in long run it is better to use polypropylene fibre.

ANNEXURE A

A) Polypropylene fibre

Normal load 1.15 kg/cm^2

1.1 Soil with no fibre content

dial gauge	proving ring	displacement (mm)	shear force(kg)	area(cm^2)	Strain	stress (kg/cm^2)
0	0	0	0	36	0	0
20	0.3	0.2	0.75	36.120	0.003	0.02
40	0.6	0.4	1.5	36.241	0.006	0.04
60	0.8	0.6	2	36.363	0.01	0.05
80	1.1	0.8	2.75	36.486	0.013	0.07
100	1.4	1	3.5	36.610	0.016	0.09
120	1.5	1.2	3.75	36.734	0.02	0.10
140	1.7	1.4	4.25	36.860	0.023	0.11
160	1.9	1.6	4.75	36.986	0.026	0.12
180	2	1.8	5	37.113	0.03	0.13
200	2.1	2	5.25	37.241	0.033	0.14
220	2.3	2.2	5.75	37.370	0.036	0.15
240	2.4	2.4	6	37.5	0.04	0.16
260	2.7	2.6	6.75	37.630	0.043	0.17
280	2.7	2.8	6.75	37.762	0.046	0.17
300	2.8	3	7	37.894	0.05	0.18
320	2.9	3.2	7.25	38.028	0.053	0.19
340	3.1	3.4	7.75	38.162	0.056	0.20
360	3.2	3.6	8	38.297	0.06	0.20
380	3.3	3.8	8.25	38.43	0.063	0.214
400	3.5	4	8.75	38.57	0.06	0.22
420	3.9	4.2	9.75	38.70	0.07	0.25
440	4.1	4.4	10.25	38.84	0.073	0.263
460	4.3	4.6	10.75	38.98	0.076	0.275
480	4.4	4.8	11	39.13	0.08	0.28
500	4.5	5	11.25	39.27	0.083	0.286
520	4.5	5.2	11.25	39.41	0.086	0.285
540	4.7	5.4	11.75	39.56	0.09	0.297
560	4.8	5.6	12	39.70	0.093	0.302
580	4.9	5.8	12.25	39.852	0.096	0.307
600	4.9	6	12.25	40	0.1	0.306
620	5	6.2	12.5	40.148	0.103	0.311
640	5.1	6.4	12.75	40.298	0.106	0.316
660	5.1	6.6	12.75	40.449	0.11	0.315
680	5.2	6.8	13	40.601	0.113	0.320

700	5.4	7	13.5	40.754	0.11	0.331
720	5.5	7.2	13.75	40.909	0.12	0.336
740	5.5	7.4	13.75	41.064	0.12	0.334
760	5.6	7.6	14	41.221	0.12	0.339
780	5.6	7.8	14	41.379	0.13	0.338
800	5.6	8	14	41.538	0.13	0.337

Table 11 Direct shear result at normal load 1.15kg/cm^2

1.2 Soil with 1% fibre content

Dial gauge	Proving ring	Shear displacement (mm)	Shear force (kg)	Strain	Shear stress (kg/cm^2)	Corrected area(cm^2)
0	0	0	0	0	0	36
2	0.2	0.2	0.48	0.003	0.01	36.120
40	0.8	0.4	01.92	0.006	0.05	36.241
60	1	0.6	2.4	0.01	0.06	36.363
80	1.4	0.8	3.36	0.013	0.09	36.486
100	1.8	1	4.32	0.016	0.12	36.610
120	2.3	1.2	5.52	0.02	0.15	36.734
140	2.6	1.4	6.24	0.023	0.17	36.860
160	2.8	1.6	6.72	0.026	0.18	36.986
180	2.9	1.8	6.96	0.03	0.19	37.113
200	3	2	7.2	0.03	.02	37.241
220	3.1	2.2	7.44	0.03	0.20	37.370
240	3.2	2.4	7.68	0.04	0.21	37.5
260	3.4	2.6	8.16	0.043	0.22	37.630
280	3.5	2.8	8.4	0.046	0.23	37.762
300	3.7	3	8.88	0.05	0.24	37.894
320	3.9	3.2	9.36	0.053	0.26	38.028
340	4.1	3.4	9.84	0.056	0.27	38.162
360	4.2	3.6	10.8	0.06	0.28	38.297
380	4.3	3.8	10.32	0.063	0.28	38.434
400	4.4	4	10.56	0.066	0.29	38.571
420	4.6	4.2	11.04	0.07	0.30	38.709
440	4.7	4.4	11.28	0.073	0.31	38.848
460	4.8	4.6	11.52	0.076	0.32	38.989
480	4.8	4.8	11.52	0.08	0.32	39.130
500	4.9	5	11.76	0.083	0.32	39.272
520	5	5.2	12	0.086	0.33	39.416
540	5	5.4	12	0.09	0.33	39.560
560	5.2	5.6	12.48	0.093	0.34	39.705
580	5.2	5.8	12.48	0.096	0.34	39.852

600	5.3	6	12.72	0.1	0.35	40
620	5.4	6.2	12.96	0.103	0.36	40.148
640	5.4	6.4	12.96	0.106	0.36	40.298
660	5.4	6.6	12.96	0.111	0.36	40.449
680	5.4	6.8	12.96	0.113	0.36	40.601
700	5.6	7	13.44	0.116	0.37	40.754
720	5.6	7.2	13.44	0.12	0.37	40.909
740	5.3	7.4	12.72	0.123	0.35	41.064
760	5.2	7.6	12.48	0.126	0.34	41.221
780	5	7.8	12	0.13	0.33	41.379
800	4.9	8	11.76	0.13	0.32	41.538

Table 12 Direct shear result at normal load 1.15kg/cm^2

1.3 Soil with 1.5% fibre content

dial gauge	proving ring	shear displacement (mm)	shear force (kg)	Strain	shear stress (kg/cm^2)	area (cm^2)
0	0	0	0	0	0	36
20	0.2	0.2	0.5	0.003	0.01	36.120
40	0.6	0.4	1.5	0.006	0.04	36.241
60	0.9	0.6	2.5	0.01	0.06	36.363
80	1.2	0.8	3	0.013	0.08	36.486
100	1.4	1	3.5	0.016	0.09	36.610
120	1.5	1.2	3.75	0.02	0.10	36.734
140	1.6	1.4	4	0.023	0.10	36.860
160	1.9	1.6	4.75	0.026	0.12	36.986
180	2	1.8	5	0.03	0.13	37.113
200	2.2	2	5.5	0.033	0.14	37.241
220	2.4	2.2	6	0.036	0.16	37.370
240	2.5	2.4	6.25	0.04	0.16	37.5
260	2.6	2.6	6.5	0.043	0.17	37.630
280	2.7	2.8	6.75	0.046	0.17	37.762
300	2.9	3	7.25	0.05	0.19	37.894
320	3.1	3.2	7.75	0.053	0.20	38.028
340	3.2	3.4	8	0.0566	0.20	38.162
360	3.3	3.6	8.25	0.06	0.21	38.297
380	3.4	3.8	8.5	0.0633	0.22	38.434
400	3.6	4	9	0.066	0.233	38.571
420	3.7	4.2	9.25	0.07	0.2389	38.709
440	3.8	4.4	9.5	0.0733	0.244	38.848
460	4	4.6	10	0.0766	0.256	38.989
480	4.1	4.8	10.25	0.08	0.261	39.130
500	4.3	5	10.75	0.0833	0.273	39.272

520	4.4	5.2	11	0.0866	0.279	39.416
540	4.5	5.4	11.25	0.09	0.284	39.560
560	4.6	5.6	11.5	0.0933	0.289	39.705
580	4.7	5.8	11.75	0.0966	0.294	39.852
600	4.9	6	12.25	0.1	0.306	40
620	4.9	6.2	12.25	0.1033	0.305	40.148
640	5	6.4	12.5	0.1066	0.310	40.298
660	5.2	6.6	13	0.11	0.321	40.449
680	5.3	6.8	13.25	0.113	0.326	40.601
700	5.4	7	13.5	0.116	0.33	40.754
720	5.5	7.2	13.75	0.12	0.336	40.909
740	5.6	7.4	14	0.123	0.340	41.064
760	5.7	7.6	14.25	0.126	0.345	41.221
780	5.7	7.8	14.25	0.13	0.345	41.379
800	5.8	8	14.5	0.13	0.349	41.538
820	5.9	8.2	14.75	0.136	0.353	41.698
840	6	8.4	15	0.14	0.358	41.860
860	6.1	8.6	15.25	0.143	0.3628	42.023
880	6.2	8.8	15.5	0.146	0.367	42.187
900	6.2	9	15.5	0.15	0.365	42.352
920	6.3	9.2	15.75	0.153	0.370	42.519
940	6.4	9.4	16	0.156	0.374	42.687
960	6.5	9.6	16.25	0.16	0.379	42.857
980	6.6	9.8	16.5	0.163	0.383	43.027
1000	6.7	10	16.75	0.166	0.387	43.2
1020	6.7	10.2	16.75	0.17	0.386	43.373
1040	6.8	10.4	17	0.173	0.390	43.548
1060	6.8	10.6	17	0.176	0.388	43.724
1080	6.9	10.8	17.25	0.18	0.392	43.902
1100	7	11	17.5	0.183	0.396	44.081
1120	7	11.2	17.5	0.186	0.395	44.262
1140	7.1	11.4	17.75	0.19	0.39	44.444
1160	7.1	11.6	17.75	0.193	0.391	44.628
1180	7.2	11.8	18	0.196	0.405	44.813
1200	7.3	12	18.25	0.2	0.401	45
1220	7.3	12.2	18.25	0.203	0.403	45.188
1240	7.3	12.4	18.25	0.206	0.402	45.378
1260	7.2	12.6	1.8	0.21	0.395	45.569
1280	7	12.8	17.5	0.213	0.38	45.762
1300	6.9	13	17.25	0.216	0.37	45.957

Table 13 Direct shear result at normal load 1.15kg/cm^2

1.4 Soil with 2.0% fibre content

dial gauge	proving ring	shear displacement (mm)	shear force (kg)	area (cm^2)	Strain	shear stress (kg/cm^2)
0	0	0	0	36	0	0
20	0.4	0.2	0.5	36.120	0.0033	0.013
40	0.6	0.4	1	36.241	0.006	0.027
60	0.8	0.6	1.5	36.363	0.01	0.041
80	0.9	0.8	2	36.486	0.013	0.054
100	1	1	2.5	36.610	0.016	0.068
120	1.2	1.2	3	36.734	0.02	0.081
140	1.4	1.4	3.5	36.860	0.023	0.094
160	1.5	1.6	4	36.986	0.026	0.008
180	1.6	1.8	4.5	37.113	0.03	0.028
200	1.8	2	5	37.241	0.033	0.134
220	2	2.2	5.5	37.370	0.036	0.147
240	2.2	2.4	6	37.5	0.04	0.16
260	2.5	2.6	6.5	37.630	0.043	0.172
280	2.6	2.8	7	37.762	0.046	0.185
300	2.6	3	7.5	37.894	0.05	0.197
320	2.6	3.2	8	38.028	0.053	0.210
340	2.6	3.4	8.5	38.162	0.056	0.222
360	2.7	3.6	9	38.297	0.06	0.235
380	2.7	3.8	9.5	38.434	0.06	0.247
400	2.8	4	1	38.571	0.066	0.259
420	2.8	4.2	10.5	38.709	0.07	0.271
440	2.8	4.4	11	38.848	0.073	0.283
460	2.8	4.6	11.5	38.989	0.076	0.294
480	2.8	4.8	12	39.130	0.08	0.306
500	2.9	5	12.5	39.272	0.083	0.318
520	2.9	5.2	13	39.416	0.086	0.329
540	3	5.4	13.5	39.560	0.09	0.341
560	3.1	5.6	14	39.705	0.093	0.352
580	3.2	5.8	14.5	39.852	0.096	0.363
600	3.2	6	15	40	0.1	0.375
620	3.3	6.2	15.5	40.148	0.103	0.386
640	3.3	6.4	16	40.298	0.106	0.397
660	3.2	6.6	16.5	40.449	0.11	0.407
680	3.1	6.8	17	40.601	0.113	0.418
700	3.1	7	17.5	40.754	0.116	0.429
720	3	7.2	18	40.909	0.12	0.44

Table 14 Direct shear result at normal load 1.15kg/cm²

1.5 soil with 2.5% fibre content

dial gauge	proving ring	shear displacement(mm)	shear force(kg)	stain	stress(kg/cm^2)
0	0	0	0	0	0
20	0.2	0.2	0.5	0.003	0.014
40	0.5	0.4	1.25	0.007	0.034
60	0.7	0.6	1.75	0.01	0.048
80	0.7	0.8	1.75	0.013	0.048
100	0.9	1	2.25	0.017	0.061
120	1	1.2	2.5	0.02	0.068
140	1.2	1.4	3	0.023	0.081
160	1.3	1.6	3.25	0.027	0.088
180	1.3	1.8	3.25	0.03	0.088
200	1.5	2	3.75	0.033	0.101
220	1.8	2.2	4.5	0.037	0.120
240	2.1	2.4	5.25	0.04	0.14
260	2.2	2.6	5.5	0.043	0.146
280	2.4	2.8	6	0.047	0.159
300	2.5	3	6.25	0.05	0.165
320	2.5	3.2	6.25	0.053	0.164
340	2.7	3.4	6.75	0.057	0.177
360	2.7	3.6	6.75	0.06	0.176
380	2.8	3.8	7	0.063	0.182
400	2.8	4	7	0.067	0.181
420	2.8	4.2	7	0.07	0.181
440	2.9	4.4	7.25	0.073	0.187
460	3	4.6	7.5	0.077	0.192
480	3	4.8	7.5	0.08	0.192
500	2.9	5	7.25	0.083	0.185
520	2.9	5.2	7.25	0.087	0.184
540	3	5.4	7.5	0.09	0.190
560	3	5.6	7.5	0.093	0.189
580	3.3	5.8	8.25	0.097	0.207
600	3.3	6	8.25	0.1	0.206
620	3.4	6.2	8.5	0.103	0.212
640	3.4	6.4	8.5	0.107	0.211
660	3.6	6.6	9	0.11	0.223
680	3.7	6.8	9.25	0.113	0.228
700	3.9	7	9.75	0.117	0.239
720	4.1	7.2	10.25	0.12	0.251
740	4.3	7.4	10.75	0.123	0.262
760	4.3	7.6	10.75	0.127	0.261
780	4.4	7.8	11	0.13	0.266

800	4.6	8	11.5	0.133	0.277
820	4.7	8.2	11.75	0.137	0.282
840	4.9	8.4	12.25	0.14	0.293
860	5	8.6	12.5	0.143	0.297
880	5.1	8.8	12.75	0.147	0.302
900	5.4	9	13.5	0.15	0.319
920	5.5	9.2	13.75	0.153	0.323
940	5.5	9.4	13.75	0.157	0.322
960	5.7	9.6	14.25	0.16	0.333
980	6	9.8	15	0.163	0.349
1000	6.1	10	15.25	0.167	0.353
1020	6.2	10.2	15.5	0.17	0.357
1040	6.3	10.4	15.75	0.173	0.362
1060	6.5	10.6	16.25	0.177	0.372
1080	6.6	10.8	16.5	0.18	0.376
1100	6.6	11	16.5	0.183	0.374
1120	6.7	11.2	16.75	0.187	0.378
1140	6.9	11.4	17.25	0.19	0.388
1160	7.1	11.6	17.75	0.193	0.398
1180	7.1	11.8	17.75	0.197	0.396
1200	7.2	12	18	0.2	0.4
1220	7.2	12.2	18	0.203	0.3983
1240	7.4	12.4	18.5	0.207	0.4077
1260	7.5	12.6	18.75	0.21	0.4115
1280	7.6	12.8	19	0.213	0.4152
1300	7.8	13	19.5	0.217	0.4243
1320	7.9	13.2	19.75	0.22	0.4279
1340	8.2	13.4	20.5	0.223	0.4423
1360	8.3	13.6	20.75	0.227	0.446
1380	8.5	13.8	21.25	0.23	0.455
1400	8.6	14	21.5	0.233	0.458
1420	8.6	14.2	21.5	0.237	0.456
1440	8.6	14.4	21.5	0.24	0.454
1460	8.6	14.6	21.5	0.243	0.452
1480	8.5	14.8	21.25	0.247	0.445
1500	8.4	15	21	0.25	0.438

Table 15Direct shear result at normal load 1.15kg/cm^2

1.6 Soil with 3% fibre content

dial gauge	proving ring	shear displacement(mm)	shear force(kg)	strain	area(cm^2)	stress(kg/cm^2)
0	0	0	0	0	36	0
2	0.2	0.02	0.5	0.0003	36.012	0.014
40	0.4	0.4	1	0.0067	36.242	0.028
60	0.6	0.6	1.5	0.01	36.364	0.041
80	0.7	0.8	1.75	0.0133	36.486	0.048
100	0.7	1	1.75	0.0167	36.610	0.048
120	0.9	1.2	2.25	0.02	36.735	0.061
140	1	1.4	2.5	0.0233	36.860	0.068
160	1.1	1.6	2.75	0.0267	36.986	0.074
180	1.2	1.8	3	0.03	37.113	0.081
200	1.2	2	3	0.0333	37.241	0.081
220	1.4	2.2	3.5	0.0367	37.370	0.094
240	1.5	2.4	3.75	0.04	37.5	0.1
260	1.7	2.6	4.25	0.0433	37.631	0.113
280	1.7	2.8	4.25	0.0467	37.762	0.113
300	1.9	3	4.75	0.05	37.895	0.125
320	2	3.2	5	0.053	38.028	0.131
340	2	3.4	5	0.057	38.163	0.131
360	2.1	3.6	5.25	0.06	38.298	0.137
380	2.2	3.8	5.5	0.063	38.434	0.143
400	2.3	4	5.75	0.067	38.571	0.149
420	2.5	4.2	6.25	0.07	38.710	0.161
440	2.7	4.4	6.75	0.073	38.849	0.174
460	2.9	4.6	7.25	0.077	38.989	0.186
480	3.1	4.8	7.75	0.08	39.130	0.198
500	3.3	5	8.25	0.083	39.273	0.210
520	3.5	5.2	8.75	0.087	39.416	0.222
540	3.6	5.4	9	0.09	39.560	0.228
560	3.8	5.6	9.5	0.093	39.706	0.239
580	4	5.8	10	0.097	39.852	0.251
600	4.2	6	10.5	0.1	40	0.263
620	4.4	6.2	11	0.103	40.149	0.274
640	4.7	6.4	11.75	0.107	40.299	0.292
660	4.7	6.6	11.75	0.11	40.449	0.290
680	4.7	6.8	11.75	0.113	40.602	0.289
700	4.7	7	11.75	0.117	40.755	0.288
720	4.7	7.2	11.75	0.12	40.909	0.287

Table 16Direct shear result at normal load 1.15kg/cm^2

2. Normal load:-0.95kg/cm^2

2.1 Soil without fibre content

dial gauge	proving ring	shear displacement (mm)	shear force (kg)	Area(cm^2)	Strain	stress(kg/cm^2)
0	0	0	0	36	0	0
20	0.4	0.2	1	36.120	0.003	0.027
40	0.6	0.4	1.5	36.241	0.006	0.041
60	0.7	0.6	1.75	36.363	0.01	0.048
80	0.9	0.8	2.25	36.486	0.013	0.061
100	1.2	1	3	36.610	0.016	0.081
120	1.5	1.2	3.75	36.734	0.02	0.102
140	1.6	1.4	4	36.860	0.023	0.108
160	1.7	1.6	4.25	36.986	0.026	0.114
180	1.9	1.8	4.75	37.113	0.03	0.127
200	2.1	2	5.25	37.241	0.033	0.140
220	2.3	2.2	5.75	37.370	0.036	0.153
240	2.5	2.4	6.25	37.5	0.04	0.165
260	2.5	2.6	6.25	37.630	0.043	0.166
280	2.6	2.8	6.5	37.762	0.046	0.172
300	2.7	3	6.75	37.894	0.05	0.178
320	2.9	3.2	7.25	38.028	0.053	0.190
340	2.9	3.4	7.25	38.162	0.056	0.189
360	3	3.6	7.5	38.297	0.06	0.195
380	3	3.8	7.5	38.434	0.063	0.195
400	3	4	7.5	38.571	0.066	0.194
420	3.1	4.2	7.75	38.709	0.07	0.200
440	3.1	4.4	7.75	38.848	0.073	0.199
460	3.2	4.6	8	38.989	0.076	0.205
480	3.4	4.8	8.5	39.130	0.08	0.217
500	3.4	5	8.5	39.272	0.083	0.216
520	3.5	5.2	8.75	39.416	0.086	0.221
540	3.6	5.4	9	39.560	0.09	0.245
560	3.6	5.6	9	39.705	0.093	0.226
580	3.7	5.8	9.25	39.852	0.096	0.232
600	3.8	6	9.5	40	0.1	0.235
620	3.8	6.2	9.5	40.148	0.103	0.236
640	3.8	6.4	9.5	40.298	0.106	0.235

Table 17 Direct shear result at normal load .95kg/cm^2

2.2 Soil with 1% fibre

dial gauge	proving ring	shear displacement (mm)	shear force (kg)	area (cm^2)	Strain	stress(kg/cm^2)
0	0	0	0	36	0	0
20	0.6	0.2	1.5	36.120	0.003	0.041
40	0.9	0.4	2.25	36.241	0.006	0.062
60	1.1	0.6	2.75	36.363	0.01	0.075
80	1.3	0.8	3.25	36.486	0.013	0.089
100	1.4	1	3.5	36.610	0.016	0.095
120	1.5	1.2	3.75	36.734	0.02	0.102
140	1.7	1.4	4.25	36.860	0.023	0.115
160	1.8	1.6	4.5	36.986	0.026	0.121
180	1.9	1.8	4.75	37.111	0.03	0.123
200	1.9	2	4.75	37.241	0.033	0.127
220	2	2.2	5	37.370	0.036	0.133
240	2.1	2.4	5.25	37.5	0.04	0.14
260	2.3	2.6	5.75	37.637	0.043	0.152
280	2.5	2.8	6.25	37.762	0.046	0.165
300	2.5	3	6.25	37.894	0.05	0.164
320	2.8	3.2	7	38.028	0.053	0.184
340	2.9	3.4	7.25	38.162	0.056	0.189
360	3	3.6	7.5	38.297	0.06	0.195
380	3	3.8	7.5	38.434	0.063	0.195
400	3.1	4	7.75	38.57	0.06	0.200
420	3.1	4.2	7.75	38.70	0.07	0.200
440	3.3	4.4	8.25	38.84	0.073	0.212
460	3.5	4.6	8.75	38.98	0.076	0.224
480	3.5	4.8	8.75	39.13	0.08	0.223
500	3.6	5	9	39.27	0.083	0.229
520	3.7	5.2	9.25	39.41	0.086	0.234
540	3.8	5.4	9.5	39.56	0.09	0.240
560	3.9	5.6	9.75	39.70	0.093	0.245
580	4	5.8	10	39.85	0.096	0.250
600	4	6	10	40	0.1	0.25
620	4.1	6.2	10.25	40.14	0.103	0.255
640	4.2	6.4	10.5	40.29	0.106	0.260
660	4.2	6.6	10.5	40.44	0.11	0.259
680	4.3	6.8	10.75	40.60	0.113	0.264
700	4.3	7	10.75	40.75	0.116	0.263
720	4.3	7.2	10.75	40.90	0.12	0.262
740	4.3	7.4	10.75	41.06	0.123	0.261

Table 18 Direct shear result at normal load .95kg/cm^2

2.3 Soil with 1.5% fibre content

dial gauge	proving ring	Shear displacement (mm)	shear force (kg)	area (cm^2)	Strain	shear stress (kg/cm^2)
0	0	0	0	36	0	0
20	0.3	0.2	0.75	36.120	0.003	0.02
40	0.6	0.4	1.5	36.241	0.006	0.04
60	0.9	0.6	2.25	36.363	0.01	0.06
80	1	0.8	2.5	36.486	0.0133	0.068
100	1.3	1	3.25	36.610	0.0166	0.088
120	1.4	1.2	3.5	36.734	0.02	0.095
140	1.6	1.4	4	36.860	0.0233	0.108
160	1.7	1.6	4.25	36.986	0.0266	0.114
180	1.8	1.8	4.5	37.113	0.03	0.121
200	2	2	5	37.241	0.0333	0.134
220	2.1	2.2	5.25	37.370	0.0366	0.140
240	2.2	2.4	5.5	37.5	0.04	0.146
260	2.3	2.6	5.75	37.630	0.0433	0.152
280	2.4	2.8	6	37.762	0.0466	0.158
300	2.5	3	6.25	37.894	0.05	0.164
320	2.6	3.2	6.5	38.028	0.0533	0.170
340	2.7	3.4	6.75	38.162	0.0566	0.17
360	2.8	3.6	7	38.297	0.06	0.182
380	2.9	3.8	7.25	38.434	0.063	0.188
400	3	4	7.5	38.571	0.066	0.194
420	3.1	4.2	7.75	38.709	0.07	0.200
440	3.1	4.4	7.75	38.848	0.073	0.199
460	3.2	4.6	8	38.989	0.076	0.205
480	3.2	4.8	8	39.130	0.08	0.204
500	3.3	5	8.25	39.272	0.083	0.210
520	3.4	5.2	8.5	39.416	0.086	0.215
540	3.5	5.4	8.75	39.560	0.09	0.221
560	3.6	5.6	9	39.705	0.093	0.226
580	3.6	5.8	9	39.852	0.096	0.225
600	3.7	6	9.25	40	0.1	0.231
620	3.8	6.2	9.5	40.148	0.103	0.236
640	3.8	6.4	9.5	40.298	0.106	0.235
660	3.9	6.6	9.75	40.449	0.11	0.241
680	4	6.8	10	40.601	0.113	0.246
700	4	7	10	40.754	0.116	0.245
720	4.1	7.2	10.25	40.909	0.12	0.250
740	4.1	7.4	10.25	41.064	0.123	0.249
760	4.2	7.6	10.5	41.221	0.126	0.254
780	4.2	7.8	10.5	41.379	0.13	0.253

800	4.3	8	10.75	41.538	0.133	0.258
820	4.3	8.2	10.75	41.698	0.136	0.257
840	4.4	8.4	11	41.860	0.14	0.262
860	4.4	8.6	11	42.023	0.143	0.261
900	4.5	9	11.25	42.352	0.15	0.265
920	4.5	9.2	11.25	42.519	0.153	0.264
940	4.6	9.4	11.5	42.687	0.156	0.269
960	4.6	9.6	11.5	42.857	0.16	0.268
980	4.7	9.8	11.75	43.027	0.163	0.273
1000	4.7	10	11.75	43.2	0.166	0.271
1020	4.8	10.2	12	43.373	0.17	0.276
1040	4.8	10.4	12	43.548	0.173	0.275

Table 19 Direct shear result at normal load .95kg/cm^2

2.4 Soil with 2% fibre content

dial gauge	proving ring	shear displacement (mm)	shear force (kg)	area (cm^2)	strain	stress (kg/cm^2)
0	0	0	0	36	0	0
20	0.1	0.2	0.25	36.120	0.003	0.006
40	0.1	0.4	0.25	36.241	0.006	0.006
60	0.1	0.6	0.25	36.363	0.01	0.006
80	0.2	0.8	0.5	36.486	0.01	0.013
100	0.3	1	0.75	36.610	0.01	0.020
120	0.5	1.2	1.25	36.734	0.02	0.034
140	0.5	1.4	1.25	36.860	0.02	0.033
160	1	1.6	2.5	36.986	0.02	0.067
180	1.2	1.8	3	37.113	0.03	0.080
200	1.4	2	3.5	37.241	0.033	0.093
220	1.6	2.2	4	37.370	0.036	0.107
240	1.7	2.4	4.25	37.5	0.04	0.113
260	2	2.6	5	37.630	0.043	0.132
280	2.2	2.8	5.5	37.762	0.046	0.145
300	2.3	3	5.75	37.894	0.05	0.151
320	2.5	3.2	6.25	38.028	0.053	0.164
340	2.5	3.4	6.25	38.162	0.056	0.163
360	2.6	3.6	6.5	38.297	0.06	0.169
380	2.8	3.8	7	38.434	0.06	0.182
400	2.9	4	7.25	38.571	0.06	0.187
420	3	4.2	7.5	38.709	0.07	0.193
440	3.2	4.4	8	38.848	0.073	0.205
460	3.4	4.6	8.5	38.989	0.076	0.218
480	3.7	4.8	9.25	39.130	0.08	0.236
500	3.8	5	9.5	39.272	0.083	0.241

520	3.9	5.2	9.75	39.416	0.086	0.247
540	4	5.4	1	39.560	0.09	0.252
560	4.2	5.6	10.5	39.705	0.093	0.264
580	4.4	5.8	11	39.852	0.096	0.276
600	4.6	6	11.5	40	0.1	0.28
620	4.9	6.2	12.25	40.148	0.103	0.305
640	4.9	6.4	12.25	40.298	0.106	0.30
660	5	6.6	12.5	40.449	0.11	0.309
680	5.1	6.8	12.75	40.601	0.113	0.314
700	5.1	7	12.75	40.754	0.116	0.312
720	5.2	7.2	13	40.909	0.12	0.317
740	5.2	7.4	13	41.064	0.123	0.316
760	5.3	7.6	13.25	41.221	0.126	0.321
780	5.3	7.8	13.25	41.379	0.13	0.320
800	5.3	8	13.25	41.538	0.13	0.318

Table 20 Direct shear result at normal load .95kg/cm^2

2.5Soil with 2.5% fibre content

dial gauge	proving ring	shear displacement(mm)	shear force(kg)	strain	area(cm^2)	stress(kg/cm^2)
0	0	0	0	0	36	0
20	0.1	0.2	0.25	0.003	36.120	0.007
40	0.2	0.4	0.5	0.007	36.242	0.014
60	0.3	0.6	0.75	0.01	36.364	0.021
80	0.3	0.8	0.75	0.013	36.486	0.021
100	0.5	1	1.25	0.017	36.610	0.034
120	0.5	1.2	1.25	0.02	36.735	0.034
140	0.7	1.4	1.75	0.023	36.860	0.047
160	0.9	1.6	2.25	0.027	36.986	0.061
180	1	1.8	2.5	0.03	37.113	0.067
200	1.1	2	2.75	0.033	37.241	0.074
220	1.2	2.2	3	0.037	37.370	0.080
240	1.2	2.4	3	0.04	37.5	0.08
260	1.4	2.6	3.5	0.043	37.631	0.093
280	1.5	2.8	3.75	0.047	37.762	0.099
300	1.6	3	4	0.05	37.895	0.106
320	1.8	3.2	4.5	0.053	38.028	0.118
340	1.8	3.4	4.5	0.057	38.163	0.118
360	2	3.6	5	0.06	38.298	0.131
380	2.1	3.8	5.25	0.063	38.434	0.137
400	2.3	4	5.75	0.067	38.571	0.149
420	2.6	4.2	6.5	0.07	38.710	0.168
440	2.7	4.4	6.75	0.073	38.849	0.174

460	2.7	4.6	6.75	0.077	38.989	0.173
480	2.8	4.8	7	0.08	39.130	0.179
500	2.8	5	7	0.083	39.273	0.178
520	3	5.2	7.5	0.087	39.416	0.190
540	3.3	5.4	8.25	0.09	39.560	0.209
560	3.4	5.6	8.5	0.093	39.706	0.214
580	3.4	5.8	8.5	0.097	39.852	0.213
600	3.6	6	9	0.1	40	0.225
620	3.8	6.2	9.5	0.103	40.149	0.237
640	4.1	6.4	10.25	0.107	40.299	0.254
660	4.2	6.6	10.5	0.11	40.449	0.260
680	4.4	6.8	11	0.113	40.602	0.271
700	4.5	7	11.25	0.117	40.755	0.276
720	4.5	7.2	11.25	0.12	40.909	0.275
740	4.7	7.4	11.75	0.123	41.065	0.286
760	4.8	7.6	12	0.127	41.221	0.291
780	4.8	7.8	12	0.13	41.379	0.29
800	4.9	8	12.25	0.133333	41.538	0.295
820	5.1	8.2	12.75	0.136667	41.699	0.306
840	5.3	8.4	13.25	0.14	41.860	0.317
860	5.4	8.6	13.5	0.143333	42.023	0.321
880	5.4	8.8	13.5	0.146667	42.188	0.32
900	5.5	9	13.75	0.15	42.353	0.325
920	5.7	9.2	14.25	0.153333	42.520	0.335
940	5.7	9.4	14.25	0.156667	42.688	0.334
960	5.8	9.6	14.5	0.16	42.857	0.338
980	5.9	9.8	14.75	0.163333	43.028	0.343
1000	6	10	15	0.166667	43.2	0.347
1020	5.9	10.2	14.75	0.17	43.373	0.340
1040	5.9	10.4	14.75	0.173333	43.548	0.339
1060	5.8	10.6	14.5	0.176667	43.725	0.332

Table 21Direct shear result at normal load .95kg/cm^2

1.6 Soil with 3% fibre content

dial gauge	proving ring	Shear displacement(mm)	shear force(kg)	strain	area(cm^2)	stress(kg/cm^2)
0	0	0	0	0	36	0
20	0.2	0.2	0.5	0.003	36.1204	0.0138
40	0.2	0.4	0.5	0.007	36.2416	0.0138
60	0.2	0.6	0.5	0.01	36.3636	0.0138
80	0.4	0.8	1	0.013	36.4865	0.0274
100	0.6	1	1.5	0.017	36.6102	0.0410
120	0.6	1.2	1.5	0.02	36.7347	0.0408
140	0.7	1.4	1.75	0.023	36.8601	0.0475
160	0.8	1.6	2	0.027	36.9863	0.0541
180	1	1.8	2.5	0.03	37.1134	0.0674
200	1.1	2	2.75	0.033	37.2414	0.0738
220	1.3	2.2	3.25	0.037	37.3702	0.0870
240	1.5	2.4	3.75	0.04	37.5	0.1
260	1.6	2.6	4	0.043	37.6307	0.1063
280	1.9	2.8	4.75	0.047	37.7622	0.1258
300	2	3	5	0.05	37.8947	0.1319
320	2.1	3.2	5.25	0.053	38.0282	0.1381
340	2.2	3.4	5.5	0.057	38.1625	0.1441
360	2.3	3.6	5.75	0.06	38.2979	0.1501
380	2.4	3.8	6	0.063	38.4342	0.1561
400	2.6	4	6.5	0.067	38.5714	0.1685
420	2.7	4.2	6.75	0.07	38.7097	0.1744
440	2.7	4.4	6.75	0.073	38.8489	0.1738
460	2.9	4.6	7.25	0.077	38.9892	0.1859
480	3.2	4.8	8	0.08	39.1304	0.2044
500	3.4	5	8.5	0.083	39.2727	0.2164
520	3.4	5.2	8.5	0.087	39.4161	0.2156
540	3.5	5.4	8.75	0.09	39.5604	0.2212
560	3.6	5.6	9	0.093	39.7059	0.2267
580	3.6	5.8	9	0.097	39.8524	0.2258
600	3.7	6	9.25	0.1	40	0.23125
620	3.7	6.2	9.25	0.103	40.1487	0.2304
640	3.8	6.4	9.5	0.107	40.2985	0.2357
660	3.9	6.6	9.75	0.11	40.4494	0.2410
680	4	6.8	10	0.113	40.6015	0.2463
700	4	7	10	0.117	40.7547	0.2454
720	3.9	7.2	9.75	0.12	40.9091	0.2383
740	3.8	7.4	9.5	0.123	41.0646	0.2313

Table 22Direct shear result at normal load .95kg/cm^2

3. Normal load .55kg/ cm^2

3.1 Soil without fibre content

dial gauge	proving ring	shear displacement (mm)	shear force (kg)	strain	shear stress (kg/cm^2)	area (cm^2)
0	0	0	0	0	0	36
20	1.2	0.2	3	0.003	0.083	36.120
40	1.5	0.4	3.75	0.006	0.103	36.241
60	1.6	0.6	4	0.01	0.11	36.363
80	1.7	0.8	4.25	0.013	0.116	36.486
100	1.7	1	4.25	0.0166	0.116	36.610
120	1.8	1.2	4.5	0.02	0.1225	36.734
140	1.9	1.4	4.75	0.023	0.128	36.860
160	1.9	1.6	4.75	0.026	0.128	36.986
180	1.9	1.8	4.75	0.03	0.127	37.113
200	2	2	5	0.033	0.134	37.241
220	2.2	2.2	5.5	0.036	0.147	37.370
240	2.2	2.4	5.5	0.04	0.146	37.5
260	2.3	2.6	5.75	0.043	0.152	37.630
280	2.3	2.8	5.75	0.046	0.152	37.762
300	2.4	3	6	0.05	0.158	37.894
320	2.5	3.2	6.25	0.053	0.164	38.028
340	2.6	3.4	6.5	0.056	0.170	38.162
360	2.7	3.6	6.75	0.06	0.176	38.297
380	2.7	3.8	6.75	0.063	0.175	38.434
400	2.7	4	6.75	0.066	0.175	38.571
420	2.8	4.2	7	0.07	0.180	38.709
440	2.8	4.4	7	0.073	0.180	38.848
460	2.7	4.6	6.75	0.076	0.173	38.989
480	2.7	4.8	6.75	0.08	0.172	39.130
500	2.6	5	6.5	0.083	0.165	39.272

Table 23 Direct shear result at normal load .55kg/cm^2

3.2 Soil with 1% fibre content

dial gauge	proving ring	shear displacement (mm)	area(cm^2)	Strain	stress (kg/cm^2)	shear force (kg)
0	0	0	36	0	0	0
20	0.2	0.2	36.120	0.003	0.01	0.05
40	0.3	0.4	36.241	0.006	0.02	0.075
60	0.8	0.6	36.363	0.01	0.055	0.2
80	1.1	0.8	36.486	0.013	0.075	0.275
100	1.5	1	36.610	0.016	.102	0.375
120	1.7	1.2	36.734	0.02	.115	0.425
140	1.9	1.4	36.860	0.023	.128	0.475
160	2	1.6	36.986	0.02	.135	0.5
180	2.1	1.8	37.113	0.03	.141	0.525
200	2.2	2	37.241	0.033	.147	0.55
220	2.3	2.2	37.370	0.036	.153	0.575
240	2.3	2.4	37.5	0.04	.153	0.575
260	2.4	2.6	37.630	0.04	.159	0.6
280	2.4	2.8	37.762	0.04	.158	0.6
300	2.5	3	37.894	0.05	.164	0.625
320	2.5	3.2	38.028	0.05	.164	0.625
340	2.5	3.4	38.162	0.05	.163	0.625
360	2.6	3.6	38.297	0.06	.169	0.65
380	2.6	3.8	38.434	0.063	.169	0.65
400	2.6	4	38.571	0.066	.168	0.65
420	2.6	4.2	38.709	0.07	.167	0.65
440	2.9	4.4	38.848	0.073	.186	0.725
460	3	4.6	38.989	0.076	.192	0.75
480	2.9	4.8	39.130	0.08	.185	0.725
500	2.9	5	39.272	0.083	.184	0.725
520	2.8	5.2	39.416	0.086	.177	0.7

Table 24 Direct shear result at normal load .55kg/cm^2

3.3 Soil with 1.5% fibre content

Dial gauge	proving ring	Shear displacement (mm)	Shear force (kg)	Strain	Stress (kg/cm^2)	Area corrected (cm^2)
0	0	0	0	0	0	36
20	0.1	0.2	0.25	0.003	0.006	36.120
40	0.6	0.4	01.5	0.006	0.041	36.241
60	0.9	0.6	2.25	0.01	0.061	36.363
80	1.4	0.8	3.5	0.01	0.095	36.486
100	1.6	1	4	0.016	0.109	36.610
120	1.6	1.2	4	0.02	0.108	36.734
140	1.6	1.4	4	0.02	0.108	36.860
160	1.7	1.6	4.25	0.02	0.114	36.986
180	1.8	1.8	4.5	0.03	0.121	37.113
200	1.8	2	4.5	0.03	0.120	37.241
220	1.9	2.2	4.75	0.03	0.127	37.370
240	2	2.4	5	0.04	0.133	37.5
260	2	2.6	5	0.04	0.132	37.630
280	2.1	2.8	5.25	0.04	0.139	37.762
300	2.2	3	5.5	0.05	0.145	37.894
320	2.2	3.2	5.5	0.053	0.144	38.028
340	2.2	3.4	5.5	0.056	0.144	38.162
360	2.4	3.6	6	0.06	0.156	38.297
380	2.4	3.8	6	0.063	0.156	38.434
400	2.5	4	6.25	0.066	0.162	38.571
420	2.6	4.2	6.5	0.07	0.167	38.709
440	2.6	4.4	6.5	0.073	0.167	38.848
460	2.6	4.6	6.5	0.07	0.166	38.989
480	2.7	4.8	6.75	0.08	0.172	39.130
500	2.8	5	7	0.08	0.178	39.277
520	2.8	5.2	7	0.08	0.177	39.416
540	2.9	5.4	7.25	0.09	0.183	39.560
560	2.9	5.6	7.25	0.093	0.182	39.705
580	3	5.8	7.5	0.096	0.188	39.852
600	3	6	7.5	0.1	0.187	40
620	3	6.2	7.5	0.103	0.186	40.148
640	3.1	6.4	7.75	0.106	0.192	40.298
660	3.1	6.6	7.75	0.11	0.191	40.449
680	3.2	6.8	8	0.113	0.197	40.601
700	3.2	7	8	0.116	0.196	40.754
720	3.2	7.2	8	0.12	0.195	40.909

Table 25 Direct shear result at normal load .55kg/cm^2

3.4 Soil with 2% fibre content

dial gauge	proving ring	shear displacement (mm)	area (cm^2)	Shearforce (kg)	Strain	Stress(kg/cm2)
0	0	0	36	0	0	0
20	0.1	0.2	36.120	0.25	0.003	0.006
40	0.2	0.4	36.241	0.5	0.006	0.013
60	0.3	0.6	36.363	0.75	0.01	0.020
80	0.4	0.8	36.486	1	0.013	0.027
100	0.5	1	36.610	1.25	0.016	0.034
120	0.6	1.2	36.734	1.5	0.02	0.040
140	0.8	1.4	36.860	2	0.023	0.054
160	0.9	1.6	36.986	2.25	0.026	0.060
180	1	1.8	37.113	2.5	0.03	0.067
200	1.2	2	37.241	3	0.033	0.080
220	1.3	2.2	37.370	3.25	0.036	0.086
240	1.6	2.4	37.5	4	0.04	0.106
260	1.9	2.6	37.630	4.75	0.043	0.126
280	2.1	2.8	37.762	5.25	0.046	0.139
300	2.2	3	37.894	5.5	0.05	0.145
320	2.5	3.2	38.028	6.25	0.053	0.164
340	2.5	3.4	38.162	6.25	0.056	0.163
360	2.6	3.6	38.297	6.5	0.06	0.169
380	2.7	3.8	38.434	6.75	0.063	0.175
400	2.7	4	38.571	6.75	0.066	0.175
420	2.8	4.2	38.709	7	0.07	0.180
440	2.9	4.4	38.848	7.25	0.073	0.186
460	2.9	4.6	38.989	7.25	0.076	0.185
480	3	4.8	39.130	7.5	0.08	0.191
500	3	5	39.272	7.5	0.083	0.190
520	3.1	5.2	39.416	7.75	0.086	0.196
540	3.2	5.4	39.560	8	0.09	0.202
560	3.2	5.6	39.705	8	0.093	0.201

Table 26 Direct shear result at normal load .55kg/cm^2

3.5 Soil with 2.5% fibre content

dial gauge	proving ring	shear displacement(mm)	strain	area(cm^2)	shear force(kg)	stress(kg/cm^2)
0	0	0	0	36	0	0
20	0.2	0.2	0.003	36.120	0.5	0.014
40	0.3	0.4	0.007	36.242	0.75	0.021
60	0.5	0.6	0.01	36.364	1.25	0.034
80	0.7	0.8	0.013	36.486	1.75	0.048
100	0.7	1	0.017	36.610	1.75	0.048
120	0.8	1.2	0.02	36.735	2	0.054
140	0.8	1.4	0.023	36.860	2	0.054
160	0.9	1.6	0.027	36.986	2.25	0.061
180	1	1.8	0.03	37.113	2.5	0.067
200	1.1	2	0.033	37.241	2.75	0.074
220	1.2	2.2	0.037	37.370	3	0.080
240	1.3	2.4	0.04	37.5	3.25	0.087
260	1.3	2.6	0.043	37.631	3.25	0.086
280	1.5	2.8	0.047	37.762	3.75	0.099
300	1.6	3	0.05	37.895	4	0.106
320	1.8	3.2	0.053	38.028	4.5	0.118
340	2	3.4	0.057	38.163	5	0.131
360	2.2	3.6	0.06	38.298	5.5	0.144
380	2.3	3.8	0.063	38.434	5.75	0.150
400	2.5	4	0.067	38.571	6.25	0.162
420	2.6	4.2	0.07	38.710	6.5	0.168
440	2.6	4.4	0.073	38.849	6.5	0.167
460	2.7	4.6	0.077	38.989	6.75	0.173
480	2.9	4.8	0.08	39.130	7.25	0.185
500	3	5	0.083	39.273	7.5	0.191
520	3	5.2	0.087	39.416	7.5	0.190
540	3.2	5.4	0.09	39.560	8	0.202
560	3.4	5.6	0.093	39.706	8.5	0.214
580	3.4	5.8	0.097	39.852	8.5	0.213
600	3.7	6	0.1	40	9.25	0.231
620	3.8	6.2	0.103	40.149	9.5	0.237
640	3.8	6.4	0.107	40.299	9.5	0.236
660	3.9	6.6	0.11	40.449	9.75	0.241
680	4	6.8	0.113	40.602	10	0.246
700	4	7	0.117	40.755	10	0.245
720	4	7.2	0.12	40.909	10	0.244
740	3.9	7.4	0.123	41.065	9.75	0.237

Table 27Direct shear result at normal load .55kg/cm^2

3.6 Soil with 3% fibre content

dial gauge	proving ring	shear displacement(mm)	shear force(kg)	strain	area(cm^2)	stress(kg/cm^2)
0	0	0	0	0	36	0
20	0.2	0.2	0.5	0.003	36.120	0.014
40	0.3	0.4	0.75	0.007	36.242	0.021
60	0.3	0.6	0.75	0.01	36.364	0.021
80	0.5	0.8	1.25	0.013	36.486	0.034
100	0.7	1	1.75	0.017	36.610	0.048
120	0.9	1.2	2.25	0.02	36.735	0.061
140	1	1.4	2.5	0.023	36.860	0.068
160	1.1	1.6	2.75	0.027	36.986	0.074
180	1.1	1.8	2.75	0.03	37.113	0.074
200	1.2	2	3	0.033	37.241	0.081
220	1.3	2.2	3.25	0.037	37.370	0.087
240	1.5	2.4	3.75	0.04	37.5	0.1
260	1.7	2.6	4.25	0.043	37.631	0.113
280	1.7	2.8	4.25	0.047	37.762	0.113
300	1.8	3	4.5	0.05	37.895	0.119
320	1.9	3.2	4.75	0.053	38.028	0.125
340	1.9	3.4	4.75	0.057	38.163	0.124
360	2	3.6	5	0.06	38.298	0.131
380	2.1	3.8	5.25	0.063	38.434	0.137
400	2.2	4	5.5	0.067	38.571	0.143
420	2.2	4.2	5.5	0.07	38.710	0.142
440	2.2	4.4	5.5	0.073	38.849	0.142
460	2.4	4.6	6	0.077	38.989	0.154
480	2.6	4.8	6.5	0.080	39.130	0.166
500	2.7	5	6.75	0.083	39.273	0.172
520	2.7	5.2	6.75	0.087	39.416	0.171
540	2.8	5.4	7	0.090	39.560	0.177
560	2.8	5.6	7	0.093	39.706	0.176
580	3	5.8	7.5	0.097	39.852	0.188
600	3.1	6	7.75	0.1	40	0.194
620	3.1	6.2	7.75	0.103	40.149	0.193
640	3.2	6.4	8	0.107	40.299	0.199
660	3.3	6.6	8.25	0.110	40.449	0.204
680	3.3	6.8	8.25	0.113	40.602	0.203
700	3.2	7	8	0.117	40.755	0.196
720	3.2	7.2	8	0.120	40.909	0.196
740	3.1	7.4	7.75	0.123	41.065	0.189

Table 28Direct shear result at normal load .55kg/cm^2

b) Coir fibre

1.Nomral load 1.15kg/cm^2

1.1 Soil with 1% fibre content

dial gauge	proving ring	shear displacement(mm)	shear force (kg)	strain	area(cm2)	stress (kg/cm^2)
0	0	0	0	0	36	0
20	0.1	0.2	0.25	0.003	36.120	0.007
40	0.2	0.4	0.5	0.007	36.242	0.014
60	0.4	0.6	1	0.010	36.364	0.028
80	0.6	0.8	1.5	0.013	36.486	0.041
100	0.7	1	1.75	0.017	36.610	0.048
120	0.8	1.2	2	0.020	36.735	0.054
140	0.8	1.4	2	0.023	36.860	0.054
160	0.9	1.6	2.25	0.027	36.986	0.061
180	0.9	1.8	2.25	0.030	37.113	0.061
200	1	2	2.5	0.033	37.241	0.067
220	1.1	2.2	2.75	0.037	37.370	0.074
240	1.1	2.4	2.75	0.040	37.500	0.073
260	1.2	2.6	3	0.043	37.631	0.080
280	1.3	2.8	3.25	0.047	37.762	0.086
300	1.5	3	3.75	0.050	37.895	0.099
340	1.7	3.4	4.25	0.057	38.163	0.111
360	1.8	3.6	4.5	0.060	38.298	0.118
380	1.9	3.8	4.75	0.063	38.434	0.124
400	2	4	5	0.067	38.571	0.130
420	2.1	4.2	5.25	0.070	38.710	0.136
440	2.4	4.4	6	0.073	38.849	0.154
460	2.5	4.6	6.25	0.077	38.989	0.160
500	2.5	5	6.25	0.083	39.273	0.159
520	2.6	5.2	6.5	0.087	39.416	0.165
540	2.7	5.4	6.75	0.090	39.560	0.171
560	2.9	5.6	7.25	0.093	39.706	0.183
580	3.1	5.8	7.75	0.097	39.852	0.194
600	3.3	6	8.25	0.100	40.000	0.206
620	3.4	6.2	8.5	0.103	40.149	0.212
640	3.4	6.4	8.5	0.107	40.299	0.211
660	3.5	6.6	8.75	0.110	40.449	0.216
680	3.6	6.8	9	0.113	40.602	0.222
700	3.8	7	9.5	0.117	40.755	0.233
720	4	7.2	10	0.120	40.909	0.244

740	4.1	7.4	10.25	0.123	41.065	0.250
760	4.3	7.6	10.75	0.127	41.221	0.261
780	4.4	7.8	11	0.130	41.379	0.266
800	4.4	8	11	0.133	41.538	0.265
820	4.7	8.2	11.75	0.137	41.699	0.282
840	4.9	8.4	12.25	0.140	41.860	0.293
860	5.1	8.6	12.75	0.143	42.023	0.303
880	5.1	8.8	12.75	0.147	42.188	0.302
900	5.2	9	13	0.150	42.353	0.307
920	5.2	9.2	13	0.153	42.520	0.306
940	5.4	9.4	13.5	0.157	42.688	0.316
960	5.4	9.6	13.5	0.160	42.857	0.315
980	5.5	9.8	13.75	0.163	43.028	0.320
1000	5.7	10	14.25	0.167	43.200	0.330
1020	6	10.2	15	0.170	43.373	0.346
1040	6	10.4	15	0.173	43.548	0.344
1060	5.9	10.6	14.75	0.177	43.725	0.337

Table 29 Direct shear result at normal load 1.15kg/cm^2

1.2 Soil with 2% fibre content

dial gauge	proving ring	shear displacement(mm)	strain	area (cm^2)	shear force(kg)	stress(kg/cm^2)
0	0	0	0	36	0	0
20	0.1	0.2	0.003	36.120	0.250	0.007
40	0.1	0.4	0.007	36.242	0.250	0.007
60	0.3	0.6	0.010	36.364	0.750	0.021
80	0.4	0.8	0.013	36.486	1.000	0.027
100	0.5	1	0.017	36.610	1.250	0.034
120	0.6	1.2	0.020	36.735	1.500	0.041
140	0.8	1.4	0.023	36.860	2.000	0.054
160	1	1.6	0.027	36.986	2.500	0.068
180	1.2	1.8	0.030	37.113	3.000	0.081
200	1.3	2	0.033	37.241	3.250	0.087
220	1.4	2.2	0.037	37.370	3.500	0.094
240	1.5	2.4	0.040	37.500	3.750	0.100
260	1.6	2.6	0.043	37.631	4.000	0.106
280	1.6	2.8	0.047	37.762	4.000	0.106
300	1.7	3	0.050	37.895	4.250	0.112
340	2	3.4	0.057	38.163	5.000	0.131

360	2.2	3.6	0.060	38.298	5.500	0.144
380	2.3	3.8	0.063	38.434	5.750	0.150
400	2.4	4	0.067	38.571	6.000	0.156
420	2.6	4.2	0.070	38.710	6.500	0.168
440	2.7	4.4	0.073	38.849	6.750	0.174
460	2.9	4.6	0.077	38.989	7.250	0.186
500	3.1	5	0.083	39.273	7.750	0.197
520	3.4	5.2	0.087	39.416	8.500	0.216
540	3.7	5.4	0.090	39.560	9.250	0.234
560	3.8	5.6	0.093	39.706	9.500	0.239
580	3.9	5.8	0.097	39.852	9.750	0.245
600	4	6	0.100	40.000	10.000	0.250
620	4.1	6.2	0.103	40.149	10.250	0.255
640	4.3	6.4	0.107	40.299	10.750	0.267
660	4.4	6.6	0.110	40.449	11.000	0.272
680	4.5	6.8	0.113	40.602	11.250	0.277
700	4.7	7	0.117	40.755	11.750	0.288
720	4.9	7.2	0.120	40.909	12.250	0.299
740	4.9	7.4	0.123	41.065	12.250	0.298
760	5	7.6	0.127	41.221	12.500	0.303
780	5.2	7.8	0.130	41.379	13.000	0.314
800	5.3	8	0.133	41.538	13.250	0.319
820	5.4	8.2	0.137	41.699	13.500	0.324
840	5.7	8.4	0.140	41.860	14.250	0.340
900	5.8	9	0.150	42.353	14.500	0.342
920	6	9.2	0.153	42.520	15.000	0.353
940	6.1	9.4	0.157	42.688	15.250	0.357
960	6.1	9.6	0.160	42.857	15.250	0.356
980	6.1	9.8	0.163	43.028	15.250	0.354

Table 30 Direct shear result at normal load 1.15kg/cm^2

1.3 Soil with 3% fibre content

dial gauge	proving ring	shear displacement(mm)	shear force(kg)	strain	Area(cm^2)	stress(kg/cm^2)
0	0	0	0	0	36	0
20	0.1	0.2	0.25	0.003	36.120	0.007
40	0.3	0.4	0.75	0.007	36.242	0.021
60	0.4	0.6	1	0.010	36.364	0.028
80	0.6	0.8	1.5	0.013	36.486	0.041
100	0.7	1	1.75	0.017	36.610	0.048
120	0.8	1.2	2	0.020	36.735	0.054
140	1	1.4	2.5	0.023	36.860	0.068
160	1.2	1.6	3	0.027	36.986	0.081
180	1.4	1.8	3.5	0.030	37.113	0.094
200	1.3	2	3.25	0.033	37.241	0.087
220	1.4	2.2	3.5	0.037	37.370	0.094
240	1.5	2.4	3.75	0.040	37.500	0.100
260	1.6	2.6	4	0.043	37.631	0.106
280	1.6	2.8	4	0.047	37.762	0.106
300	1.7	3	4.25	0.050	37.895	0.112
340	2	3.4	5	0.057	38.163	0.131
360	2.2	3.6	5.5	0.060	38.298	0.144
380	2.3	3.8	5.75	0.063	38.434	0.150
400	2.4	4	6	0.067	38.571	0.156
420	2.6	4.2	6.5	0.070	38.710	0.168
440	2.7	4.4	6.75	0.073	38.849	0.174
460	2.9	4.6	7.25	0.077	38.989	0.186
500	3.1	5	7.75	0.083	39.273	0.197
520	3.5	5.2	8.75	0.087	39.416	0.222
540	3.6	5.4	9	0.090	39.560	0.228
560	3.8	5.6	9.5	0.093	39.706	0.239
580	3.8	5.8	9.5	0.097	39.852	0.238
600	4	6	10	0.100	40.000	0.250
620	4.2	6.2	10.5	0.103	40.149	0.262
640	4.3	6.4	10.75	0.107	40.299	0.267
660	4.5	6.6	11.25	0.110	40.449	0.278
680	4.7	6.8	11.75	0.113	40.602	0.289
700	4.8	7	12	0.117	40.755	0.294
720	4.9	7.2	12.25	0.120	40.909	0.299
740	5.1	7.4	12.75	0.123	41.065	0.310
760	5.3	7.6	13.25	0.127	41.221	0.321
780	5.5	7.8	13.75	0.130	41.379	0.332
800	5.5	8	13.75	0.133	41.538	0.331

820	5.6	8.2	14	0.137	41.699	0.336
840	5.8	8.4	14.5	0.140	41.860	0.346
860	5.9	8.6	14.75	0.143	42.023	0.351
880	6	8.8	15	0.147	42.188	0.356
900	6.1	9	15.25	0.150	42.353	0.360
920	6.1	9.2	15.25	0.153	42.520	0.359
940	6.2	9.4	15.5	0.157	42.688	0.363
960	6.4	9.6	16	0.160	42.857	0.373
980	6.5	9.8	16.25	0.163	43.028	0.378

Table 31 Direct shear result at normal load 1.15kg/cm^2

1.4 Soil with 4% fibre content

dial gauge	proving ring	shear displacement(mm)	shear force(kg)	strain	area(cm^2)	stress(kg/cm^2)
0	0	0	0	0	36	0
20	0.1	0.2	0.25	0.003	36.120	0.007
40	0.2	0.4	0.5	0.007	36.242	0.014
60	0.4	0.6	1	0.010	36.364	0.028
80	0.6	0.8	1.5	0.013	36.486	0.041
100	0.7	1	1.75	0.017	36.610	0.048
120	0.7	1.2	1.75	0.020	36.735	0.048
140	0.8	1.4	2	0.023	36.860	0.054
160	0.9	1.6	2.25	0.027	36.986	0.061
180	1	1.8	2.5	0.030	37.113	0.067
200	1.1	2	2.75	0.033	37.241	0.074
220	1.2	2.2	3	0.037	37.370	0.080
240	1.3	2.4	3.25	0.040	37.500	0.087
260	1.4	2.6	3.5	0.043	37.631	0.093
280	1.4	2.8	3.5	0.047	37.762	0.093
300	1.5	3	3.75	0.050	37.895	0.099
320	1.7	3.2	4.25	0.053	38.028	0.112
340	1.9	3.4	4.75	0.057	38.163	0.124
360	2.1	3.6	5.25	0.060	38.298	0.137
380	2.2	3.8	5.5	0.063	38.434	0.143
400	2.4	4	6	0.067	38.571	0.156
420	2.5	4.2	6.25	0.070	38.710	0.161
440	2.5	4.4	6.25	0.073	38.849	0.161
460	2.7	4.6	6.75	0.077	38.989	0.173
480	2.8	4.8	7	0.080	39.130	0.179

500	3	5	7.5	0.083	39.273	0.191
520	3.1	5.2	7.75	0.087	39.416	0.197
540	3.2	5.4	8	0.090	39.560	0.202
560	3.3	5.6	8.25	0.093	39.706	0.208
580	3.4	5.8	8.5	0.097	39.852	0.213
600	3.5	6	8.75	0.100	40.000	0.219
620	3.6	6.2	9	0.103	40.149	0.224
640	3.8	6.4	9.5	0.107	40.299	0.236
660	3.9	6.6	9.75	0.110	40.449	0.241
680	4.1	6.8	10.25	0.113	40.602	0.252
700	4.2	7	10.5	0.117	40.755	0.258
720	4.3	7.2	10.75	0.120	40.909	0.263
740	4.4	7.4	11	0.123	41.065	0.268
760	4.5	7.6	11.25	0.127	41.221	0.273
780	4.5	7.8	11.25	0.130	41.379	0.272
800	4.7	8	11.75	0.133	41.538	0.283
820	4.9	8.2	12.25	0.137	41.699	0.294
840	5.1	8.4	12.75	0.140	41.860	0.305
860	5.1	8.6	12.75	0.143	42.023	0.303
880	5	8.8	12.5	0.147	42.188	0.296

Table 32 Direct shear result at normal load 1.15kg/cm^2

2.Normal load 0.95 kg/cm^2

Soil with 1% fibre content

dial gauge	proving ring	shear displacement(mm)	shear force(kg)	strain	area(cm^2)	stress(kg/cm^2)
0	0	0	0	0	36	0
20	0	0.2	0	0.003	36.120	0.000
40	0.2	0.4	0.5	0.007	36.242	0.014
60	0.3	0.6	0.75	0.010	36.364	0.021
80	0.4	0.8	1	0.013	36.486	0.027
100	0.5	1	1.25	0.017	36.610	0.034
120	0.7	1.2	1.75	0.020	36.735	0.048
140	0.9	1.4	2.25	0.023	36.860	0.061
160	1	1.6	2.5	0.027	36.986	0.068
180	1.1	1.8	2.75	0.030	37.113	0.074
200	1.3	2	3.25	0.033	37.241	0.087
220	1.5	2.2	3.75	0.037	37.370	0.100

240	1.7	2.4	4.25	0.040	37.500	0.113
260	1.8	2.6	4.5	0.043	37.631	0.120
280	2	2.8	5	0.047	37.762	0.132
300	2.1	3	5.25	0.050	37.895	0.139
320	2.3	3.2	5.75	0.053	38.028	0.151
340	2.3	3.4	5.75	0.057	38.163	0.151
360	2.5	3.6	6.25	0.060	38.298	0.163
380	2.6	3.8	6.5	0.063	38.434	0.169
400	2.7	4	6.75	0.067	38.571	0.175
420	2.7	4.2	6.75	0.070	38.710	0.174
440	2.9	4.4	7.25	0.073	38.849	0.187
460	3	4.6	7.5	0.077	38.989	0.192
480	3.2	4.8	8	0.080	39.130	0.204
500	3.4	5	8.5	0.083	39.273	0.216
520	3.5	5.2	8.75	0.087	39.416	0.222
540	3.6	5.4	9	0.090	39.560	0.228
560	3.8	5.6	9.5	0.093	39.706	0.239
580	3.9	5.8	9.75	0.097	39.852	0.245
600	4	6	10	0.100	40.000	0.250
620	4.1	6.2	10.25	0.103	40.149	0.255
640	4.1	6.4	10.25	0.107	40.299	0.254
660	4.2	6.6	10.5	0.110	40.449	0.260
680	4.2	6.8	10.5	0.113	40.602	0.259

Table 33 Direct shear result at normal load 0.95 kg/cm^2

2.2 Soil with 2% fibre content

dial gauge	proving ring	shear displacement(mm)	shear force (kg)	strain	area(cm^2)	stress(kg/cm^2)
0	0	0	0	0	36	0
20	0.2	0.2	0.5	0.003	36.120	0.014
40	0.3	0.4	0.75	0.007	36.242	0.021
60	0.5	0.6	1.25	0.010	36.364	0.034
80	0.7	0.8	1.75	0.013	36.486	0.048
100	1	1	2.5	0.017	36.610	0.068
120	1.1	1.2	2.75	0.020	36.735	0.075
140	1.3	1.4	3.25	0.023	36.860	0.088
160	1.3	1.6	3.25	0.027	36.986	0.088
180	1.4	1.8	3.5	0.030	37.113	0.094
200	1.6	2	4	0.033	37.241	0.107

220	1.7	2.2	4.25	0.037	37.370	0.114
240	1.9	2.4	4.75	0.040	37.500	0.127
260	2.1	2.6	5.25	0.043	37.631	0.140
280	2.3	2.8	5.75	0.047	37.762	0.152
300	2.4	3	6	0.050	37.895	0.158
320	2.4	3.2	6	0.053	38.028	0.158
340	2.7	3.4	6.75	0.057	38.163	0.177
360	2.9	3.6	7.25	0.060	38.298	0.189
380	3.1	3.8	7.75	0.063	38.434	0.202
400	3.2	4	8	0.067	38.571	0.207
420	3.3	4.2	8.25	0.070	38.710	0.213
440	3.5	4.4	8.75	0.073	38.849	0.225
460	3.7	4.6	9.25	0.077	38.989	0.237
480	3.8	4.8	9.5	0.080	39.130	0.243
500	3.9	5	9.75	0.083	39.273	0.248
520	4	5.2	10	0.087	39.416	0.254
540	4.2	5.4	10.5	0.090	39.560	0.265
560	4.3	5.6	10.75	0.093	39.706	0.271
580	4.4	5.8	11	0.097	39.852	0.276
600	4.2	6	10.5	0.100	40.000	0.263

Table 34 Direct shear result at normal load 0.95 kg/cm^2

2.3 Soil with 3% fibre content

Dial gauge	proving ring	shear displacement(mm)	shear force (kg)	strain	area(cm^2)	stress (kg/cm^2)
0	0	0	0	0	36	0
20	0.1	0.2	0.25	0.003	36.120	0.007
40	0.2	0.4	0.5	0.007	36.242	0.014
60	0.4	0.6	1	0.010	36.364	0.028
80	0.6	0.8	1.5	0.013	36.486	0.041
100	0.7	1	1.75	0.017	36.610	0.048
120	0.8	1.2	2	0.020	36.735	0.054
140	0.8	1.4	2	0.023	36.860	0.054

160	0.9	1.6	2.25	0.027	36.986	0.061
180	0.9	1.8	2.25	0.030	37.113	0.061
200	1	2	2.5	0.033	37.241	0.067
220	1.1	2.2	2.75	0.037	37.370	0.074
240	1.1	2.4	2.75	0.040	37.500	0.073
260	1.2	2.6	3	0.043	37.631	0.080
280	1.3	2.8	3.25	0.047	37.762	0.086
300	1.5	3	3.75	0.050	37.895	0.099
340	1.7	3.4	4.25	0.057	38.163	0.111
360	1.8	3.6	4.5	0.060	38.298	0.118
380	1.9	3.8	4.75	0.063	38.434	0.124
400	2	4	5	0.067	38.571	0.130
420	2.1	4.2	5.25	0.070	38.710	0.136
440	2.4	4.4	6	0.073	38.849	0.154
460	2.5	4.6	6.25	0.077	38.989	0.160
500	2.6	5	6.5	0.083	39.273	0.166
520	2.6	5.2	6.5	0.087	39.416	0.165
540	2.7	5.4	6.75	0.090	39.560	0.171
560	2.8	5.6	7	0.093	39.706	0.176
580	3.1	5.8	7.75	0.097	39.852	0.194
600	3.3	6	8.25	0.100	40.000	0.206
620	3.4	6.2	8.5	0.103	40.149	0.212
640	3.4	6.4	8.5	0.107	40.299	0.211
660	3.5	6.6	8.75	0.110	40.449	0.216
680	3.7	6.8	9.25	0.113	40.602	0.228
700	3.8	7	9.5	0.117	40.755	0.233
720	3.9	7.2	9.75	0.120	40.909	0.238
740	4.1	7.4	10.25	0.123	41.065	0.250
760	4.3	7.6	10.75	0.127	41.221	0.261
780	4.4	7.8	11	0.130	41.379	0.266
800	4.5	8	11.25	0.133	41.538	0.271
820	4.7	8.2	11.75	0.137	41.699	0.282
840	4.9	8.4	12.25	0.140	41.860	0.293
860	5.1	8.6	12.75	0.143	42.023	0.303
880	5.1	8.8	12.75	0.147	42.188	0.302
900	5	9	12.5	0.150	42.353	0.295
920	5	9.2	12.5	0.153	42.520	0.294

Table 35 Direct shear result at normal load 0.95 kg/cm^2

2.4 Soil with 4% fibre content

dial gauge	proving ring	shear displacement(mm)	shear force(kg)	strain	area(cm^2)	stress(kg/cm^2)
0	0	0	0	0	36	0
20	0.1	0.2	0.25	0.003	36.120	0.007
40	0.2	0.4	0.5	0.007	36.242	0.014
60	0.4	0.6	1	0.010	36.364	0.028
80	0.5	0.8	1.25	0.013	36.486	0.034
100	0.6	1	1.5	0.017	36.610	0.041
120	0.7	1.2	1.75	0.020	36.735	0.048
140	0.9	1.4	2.25	0.023	36.860	0.061
160	0.9	1.6	2.25	0.027	36.986	0.061
180	1	1.8	2.5	0.030	37.113	0.067
200	1.1	2	2.75	0.033	37.241	0.074
220	1.2	2.2	3	0.037	37.370	0.080
240	1.3	2.4	3.25	0.040	37.500	0.087
260	1.3	2.6	3.25	0.043	37.631	0.086
280	1.4	2.8	3.5	0.047	37.762	0.093
300	1.5	3	3.75	0.050	37.895	0.099
320	1.7	3.2	4.25	0.053	38.028	0.112
340	1.9	3.4	4.75	0.057	38.163	0.124
360	2.1	3.6	5.25	0.060	38.298	0.137
380	2.2	3.8	5.5	0.063	38.434	0.143
400	2.4	4	6	0.067	38.571	0.156
420	2.5	4.2	6.25	0.070	38.710	0.161
440	2.5	4.4	6.25	0.073	38.849	0.161
460	2.7	4.6	6.75	0.077	38.989	0.173
480	2.8	4.8	7	0.080	39.130	0.179
500	3	5	7.5	0.083	39.273	0.191
520	3.1	5.2	7.75	0.087	39.416	0.197
540	3.2	5.4	8	0.090	39.560	0.202
560	3.3	5.6	8.25	0.093	39.706	0.208
580	3.4	5.8	8.5	0.097	39.852	0.213
600	3.5	6	8.75	0.100	40.000	0.219
620	3.6	6.2	9	0.103	40.149	0.224
640	3.8	6.4	9.5	0.107	40.299	0.236
660	3.9	6.6	9.75	0.110	40.449	0.241
680	4.1	6.8	10.25	0.113	40.602	0.252
700	4.2	7	10.5	0.117	40.755	0.258

720	4.3	7.2	10.75	0.120	40.909	0.263
740	4.4	7.4	11	0.123	41.065	0.268
760	4.5	7.6	11.25	0.127	41.221	0.273
780	4.5	7.8	11.25	0.130	41.379	0.272

Table 36 Direct shear result at normal load 0.95 kg/cm^2

3.Normal load 0.55 kg/cm^2

3.1 Soil with 1% fibre content

dial gauge	proving ring	shear displacement(mm)	strain	shear force (kg)	area(cm^2)	stresskg/cm^2)
0	0	0	0	0	36	0
20	0.1	0.2	0.003	0.250	36.120	0.007
40	0.2	0.4	0.007	0.500	36.242	0.014
60	0.3	0.6	0.010	0.750	36.364	0.021
80	0.4	0.8	0.013	1.000	36.486	0.027
100	0.4	1	0.017	1.000	36.610	0.027
120	0.6	1.2	0.020	1.500	36.735	0.041
140	0.6	1.4	0.023	1.500	36.860	0.041
160	0.7	1.6	0.027	1.750	36.986	0.047
180	0.8	1.8	0.030	2.000	37.113	0.054
200	0.8	2	0.033	2.000	37.241	0.054
220	0.8	2.2	0.037	2.000	37.370	0.054
240	1	2.4	0.040	2.500	37.500	0.067
260	1.3	2.6	0.043	3.250	37.631	0.086
280	1.3	2.8	0.047	3.250	37.762	0.086
300	1.5	3	0.050	3.750	37.895	0.099
320	1.7	3.2	0.053	4.250	38.028	0.112
340	1.8	3.4	0.057	4.500	38.163	0.118
360	2.1	3.6	0.060	5.250	38.298	0.137
380	2.4	3.8	0.063	6.000	38.434	0.156
400	2.4	4	0.067	6.000	38.571	0.156
420	2.6	4.2	0.070	6.500	38.710	0.168
440	2.7	4.4	0.073	6.750	38.849	0.174
460	2.7	4.6	0.077	6.750	38.989	0.173
480	2.9	4.8	0.080	7.250	39.130	0.185
500	3.1	5	0.083	7.750	39.273	0.197
520	3.1	5.2	0.087	7.750	39.416	0.197

540	3.2	5.4	0.090	8.000	39.560	0.202
560	3.3	5.6	0.093	8.250	39.706	0.208
580	3.4	5.8	0.097	8.500	39.852	0.213
600	3.6	6	0.100	9.000	40.000	0.225
620	3.6	6.2	0.103	9.000	40.149	0.224
640	3.6	6.4	0.107	9.000	40.299	0.223
660	3.5	6.6	0.110	8.750	40.449	0.216

Table 37 Direct shear result at normal load 0.55 kg/cm^2

1.2 Soil with 2% fibre content

dial gauge	proving ring	shear displacement(mm)	strain	shear force (kg)	area(cm^2)	Stress(kg/cm^2)
0	0	0	0	0	36	0
20	0.1	0.2	0.003	0.250	36.120	0.007
40	0.2	0.4	0.007	0.500	36.242	0.014
60	0.4	0.6	0.010	1.000	36.364	0.028
80	0.5	0.8	0.013	1.250	36.486	0.034
100	0.5	1	0.017	1.250	36.610	0.034
120	0.7	1.2	0.020	1.750	36.735	0.048
140	0.7	1.4	0.023	1.750	36.860	0.047
160	0.8	1.6	0.027	2.000	36.986	0.054
180	0.9	1.8	0.030	2.250	37.113	0.061
200	0.9	2	0.033	2.250	37.241	0.060
220	1	2.2	0.037	2.500	37.370	0.067
240	1	2.4	0.040	2.500	37.500	0.067
260	1.2	2.6	0.043	3.000	37.631	0.080
280	1.2	2.8	0.047	3.000	37.762	0.079
300	1.4	3	0.050	3.500	37.895	0.092
320	1.7	3.2	0.053	4.250	38.028	0.112
340	1.9	3.4	0.057	4.750	38.163	0.124
360	2.2	3.6	0.060	5.500	38.298	0.144
380	2.4	3.8	0.063	6.000	38.434	0.156
400	2.5	4	0.067	6.250	38.571	0.162
420	2.6	4.2	0.070	6.500	38.710	0.168
440	2.7	4.4	0.073	6.750	38.849	0.174
460	2.8	4.6	0.077	7.000	38.989	0.180
480	2.8	4.8	0.080	7.000	39.130	0.179
500	2.9	5	0.083	7.250	39.273	0.185

520	3	5.2	0.087	7.500	39.416	0.190
540	3	5.4	0.090	7.500	39.560	0.190
560	3.1	5.6	0.093	7.750	39.706	0.195
580	3.2	5.8	0.097	8.000	39.852	0.201
600	3.4	6	0.100	8.500	40.000	0.213
620	3.6	6.2	0.103	9.000	40.149	0.224
640	3.7	6.4	0.107	9.250	40.299	0.230
660	3.9	6.6	0.110	9.750	40.449	0.241
680	3.8	6.8	0.113	9.500	40.602	0.234
700	3.8	7	0.117	9.500	40.755	0.233

Table 38 Direct shear result at normal load 0.55 kg/cm^2

1.3 Soil with 3% fibre content

dial gauge	proving ring	shear displacement(mm)	shear force(kg)	strain	area(cm^2)	stress(kg/cm^2)
0	0	0	0	0	36	0
20	0.1	0.2	0.25	0.003	36.120	0.007
40	0.3	0.4	0.75	0.007	36.242	0.021
60	0.5	0.6	1.25	0.010	36.364	0.034
80	0.6	0.8	1.5	0.013	36.486	0.041
100	0.6	1	1.5	0.017	36.610	0.041
120	0.7	1.2	1.75	0.020	36.735	0.048
140	0.7	1.4	1.75	0.023	36.860	0.047
160	0.8	1.6	2	0.027	36.986	0.054
180	0.9	1.8	2.25	0.030	37.113	0.061
200	1.1	2	2.75	0.033	37.241	0.074
220	1.2	2.2	3	0.037	37.370	0.080
240	1.2	2.4	3	0.040	37.500	0.080
260	1.3	2.6	3.25	0.043	37.631	0.086
280	1.4	2.8	3.5	0.047	37.762	0.093
300	1.5	3	3.75	0.050	37.895	0.099
340	1.7	3.4	4.25	0.057	38.163	0.111
360	1.9	3.6	4.75	0.060	38.298	0.124
380	2	3.8	5	0.063	38.434	0.130
400	2.1	4	5.25	0.067	38.571	0.136
420	2.1	4.2	5.25	0.070	38.710	0.136
440	2.2	4.4	5.5	0.073	38.849	0.142
460	2.5	4.6	6.25	0.077	38.989	0.160
500	2.6	5	6.5	0.083	39.273	0.166
520	2.7	5.2	6.75	0.087	39.416	0.171

540	2.8	5.4	7	0.090	39.560	0.177
560	2.9	5.6	7.25	0.093	39.706	0.183
580	3	5.8	7.5	0.097	39.852	0.188
600	3.1	6	7.75	0.100	40.000	0.194
620	3.2	6.2	8	0.103	40.149	0.199
640	3.3	6.4	8.25	0.107	40.299	0.205
660	3.5	6.6	8.75	0.110	40.449	0.216
680	3.6	6.8	9	0.113	40.602	0.222
700	3.7	7	9.25	0.117	40.755	0.227
720	3.8	7.2	9.5	0.120	40.909	0.232
740	4.1	7.4	10.25	0.123	41.065	0.250
760	4.2	7.6	10.5	0.127	41.221	0.255
780	4.3	7.8	10.75	0.130	41.379	0.260
800	4.4	8	11	0.133	41.538	0.265

Table 39 Direct shear result at normal load 0.55 kg/cm^2

1.4 Soil with 4% fibre content

dial gauge	proving ring	shear displacement(mm)	shear force(kg)	strain	area(cm^2)	stress(kg/cm^2)
0	0	0	0	0	36	0
20	0.1	0.2	0.25	0.003	36.120	0.007
40	0.2	0.4	0.5	0.007	36.242	0.014
60	0.4	0.6	1	0.010	36.364	0.028
80	0.5	0.8	1.25	0.013	36.486	0.034
100	0.6	1	1.5	0.017	36.610	0.041
120	0.7	1.2	1.75	0.020	36.735	0.048
140	0.9	1.4	2.25	0.023	36.860	0.061
160	0.9	1.6	2.25	0.027	36.986	0.061
180	1	1.8	2.5	0.030	37.113	0.067
200	1.1	2	2.75	0.033	37.241	0.074
220	1.2	2.2	3	0.037	37.370	0.080
240	1.3	2.4	3.25	0.040	37.500	0.087
260	1.3	2.6	3.25	0.043	37.631	0.086
280	1.4	2.8	3.5	0.047	37.762	0.093
300	1.5	3	3.75	0.050	37.895	0.099
320	1.7	3.2	4.25	0.053	38.028	0.112
340	1.9	3.4	4.75	0.057	38.163	0.124
360	2.1	3.6	5.25	0.060	38.298	0.137

380	2.2	3.8	5.5	0.063	38.434	0.143
400	2.4	4	6	0.067	38.571	0.156
420	2.5	4.2	6.25	0.070	38.710	0.161
440	2.5	4.4	6.25	0.073	38.849	0.161
460	2.7	4.6	6.75	0.077	38.989	0.173
480	2.8	4.8	7	0.080	39.130	0.179
500	3	5	7.5	0.083	39.273	0.191
520	3.1	5.2	7.75	0.087	39.416	0.197
540	3.2	5.4	8	0.090	39.560	0.202
560	3.3	5.6	8.25	0.093	39.706	0.208
580	3.4	5.8	8.5	0.097	39.852	0.213
600	3.5	6	8.75	0.100	40.000	0.219

Table 40 Direct shear result at normal load 0.55 kg/cm^2

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