CHAPTER-1

INTRODUCTION

1.1 INTRODUCTION

Foundation is a very important part of the structure because entire structure rest on the foundation. In order to make the foundation strong, soil around it plays a critical role. To work with soil it is very much essential to know about the property of soil and which factor affects its behavior. It is very much essential to know about the factor which improve the property of soil which is used for construction work i.e. soil stabilization process.

Soil stabilization is an important technique. There are various methods of soil stabilization, but we have to choose such method which is cost effective and more durable. The use of fibre for soil stabilization is one of the innovative method rather than other method of soil stabilization which is less costly and durable one. Other stabilizations like cement stabilizations, lime stabilization are not economical. So the uses of the fibre play an important role in soil stabilization. Fibre works as reinforcement with soil and increase the binding property of the soil. The length of the fibre is assessed according to nature and place of work. According to the previous journal we found out that fibre give good result when it is reinforced with soil. So I decided to choose natural fibre (Jute fibre) and synthetic fibre (Polypropylene fibre) which are reinforced with expansive soil and enhance its property.

In Indian about 20% of land area is covered by expansive soil. Mainly expansive soil is found in central region and southern region of India. In this report I studied the central region (Madhya Pradesh), where I found most of the buildings were damaged and many cracks found in road due to swelling and shrinkage behavior of this soil. So I did my project for the improvement of expansive soil using synthetic fibre (Polypropylene fibre) and natural fibre (Jute fibre) and compare which one is best and economical, and overcame such type of problem at great instant. The Polypropylene fibre and Jute fibre is an innovative technique to increase the engineering property of the soil.

If we study the different types of soil, Expansive soil is very week soil in nature. Expansive soil are clay of high plasticity and they are expansive due to presence of large percentage of expansive clay minerals i.e. monmorillonite.

Fig.1 Expansive Soil at site

The shearing strength of this type of soil is very less and these types of the soil are highly compressible and have low bearing capacity. Expansive soil is occurring in climate zones characteristics by alternate dry and wet season. Due to dry and wet season this type of soil experience periodically large swelling and shrinkage behavior. Such cyclic Swell-shrink movement of the ground causes damage and distressed the structure. So we can't construct structure directly on such type of soil. Improvement of Expansive soil is very essential. So when the Jute fibre and Polypropylene fibre is mixed with expansive soil the fibre fills the void of the soil and absorbs moisture when the soil is contact with water. So due to such condition it reduces the tendency of the swelling behavior of the soil and increases the shearing and bearing capacity of the soil. Basically fibre works like reinforcement. When we use fibre as compared to the other stabilizing agent it will give more strength in compression. In compression failure, cracks formed are less but there is a huge bulging of the soil specimen which is reinforced with soil. The expansive soils used in the study were collected from depths between 0.3-1.0m below ground level from District Morina Madhya Pradesh. The physical appearance of this soil are: (1). Black or darkish grey to brown colour (2).Shrinkage and swelling behaviour when it contact with moisture condition (3). Crack and heave formed and the cracks width are 15-20 cm.

This soil is mixed with Polypropylene fibre and Jute fibre at different percentage and the various test performed. The result found out by such experiment is good and shows the improvement of the soil. Basically fibre reduces the swell- shrink behaviour of the soil and enhance its property. So the use of the fibre is an advantage according to civil engineering point of view in soil stabilization process.

1.2 JUTE FIBRE:

Jute fibre is also an innovative technique to improve the property of the soil. In all over the world, India has become the 2nd place to the production of Jute fibre. Jute fibre is a natural fibre and it is produced in north-East in India and Bangladesh in huge amount. Mainly Jute is used to make carpet etc. Today Jute is used as geo-textiles material in slope, embankment to prevent soil from soil erosion and also Jute become converted in to its fibre and mix with soil to enhance the property of the soil. Jute fibre is recyclable and thus environmental friendly. Jute fibre is a natural fibre with golden and silky shine hence it is called golden fibre.

Fig.2 Jute Fibre

Jute fibre has tendency to absorb moisture, excellent durability and have high initial tensile strength. Due to such type of behaviour, Jute fibre is used for soil stabilization. The basic function of Jute fibre is separation, filtration, and for reinforcement. Jute fibre have different length but we have to use the Jute fibre of length 12mm which can mix easily with soil and give good reinforcement to the soil.

1.3 POLYPROPYLENE FIBRE:

In Morden age, the fibre is used in various fields. Polypropylene fibre is synthetic fibre and it is used to enhance the property of the concrete. But now a day's Polypropylene fibre is used for the soil stabilization. The Polypropylene fibre mixed with soil and it work as a reinforced material. It is called fibre- reinforced stabilization. Polypropylene fibre is a synthetic fibre and it is obtained from the waste material. It is cost effective material and improves the property of the soil when it is reinforced with soil. It is used to reduce the plastic, shrinkage behaviour of the soil, improve the impact strength and increases the fatigue resistance of the soil mass. It is used as reinforced for water contaminated soil liners

Fig.3 Polypropylene Fibre

1.4 ENVIROMENTAL IMPACT:

Jute fibre is obtained from plants by the natural process. Jute fibre is recycled and thus environmental friendly. Without any hazards we can dispose of the Jute fibre in an environment. Jute has good insulating and has low thermal conductivity. It will not make any skin –irritation.

Polypropylene fibre is obtained from by- product. It emits lower green house gases and has less energy use as compared to other fibre. Polypropylene fibre has low impact on the environment because it has non-toxic waste, non toxic emission. It is chemically inert, so it does not break down with harmful effect on human and environment. As compared to the other stabilization additives it is more environmental friendly.

So, according to the study, both fibre are environment friendly and have no impact on the environment.

1.5 NEED FOR THE RESEARCH:

Many researchers have developed various techniques for the improvement of the soil. Stabilization of soil with lime, cement or other additive agents is more popular. But all these methods are costly. The use of randomly distributed fibre i.e. Polypropylene fibre and Jute fibre is an innovative technique that solves the entire geotechnical problem. The need of this research coming in mind, because in growing age all additive agent are found in less amount in nature and some countries are not afford it in excess amount, so the use of the Jute fibre and Polypropylene fibre is an innovative techniques because Jute is natural fibre and it is obtained in huge amount and second one is Polypropylene fibre which is also find in excess. Both fibres have very cost effective and they have no any environmental impact.

1.6 OBJECTIVE:

The above goal can be achieved by considering following objective:

1. Undertake the literature review to establish the current position of the research relating to topic.
2. Investigate the engineering property of Expansive soil
3. Investigate the strength gain component which is associated with Expansive soil by mixing of fibre
4. Compare the result of both fibre.
5. Establishment of better Suitable fibre i.e. Jute fibre and Polypropylene fibre with expansive soil. So, that it will give optimum result to the researcher.

1.7 SCOPE OF WORK:

The present study attempts to understand the effectiveness of jute fibre and randomly oriented polypropylene fibres for the stabilization of expansive soil and controlling the swelling behaviour of this soil. So I divided the whole work in to five chapters and these chapters are divided in such a way that only specific task and deadlines are shown. The first chapter is the introductory part in which the report tells us about what are expansive soil, Jute fibre and Polypropylene fibre and what the impact of this material on environment is. The Second chapter is literature review. The third chapter is experimental investigation and methodology used acc to IS specification. The fourth chapter is Result and discussion part in which I did various experiments like UCS, Compaction, CBR, Direct shear, tensile test of soil with Jute Fibre and polypropylene fibre and study the effect of these fibre. The fifth chapter is comparison of result in which I compared the results of both fibre The sixth chapter is the Conclusion part, in which I concluded which Fibre is best and give stability to the soil. In this chapter I also formulate the scope of future studies.

CHAPTER-2

LITRATURE REVIEW

2.1 INTRODUTION

In India, a vast capital is spent on infrastructure such as buildings and roads. But due to natural clematises, most of the structures are damaged and there is a huge loss to the economy of the country. These natural climates effect only when there is not proper designing of the structure or the structure built up on the poor quality of soil. So our initial work in construction to study the quality of the soil and the parameter which affect its behaviour. If the quality of the soil is poor then geotechnical engineer first work to improve the property of the soil. So Engineers choose soil stabilization techniques for improving the quality of the soil. There are different types of material used for stabilization, but these materials are costly, so engineers try to improve the property of the soil with different method and techniques.

We already studied in chapter-1 that soil improvement means to increase the shear strength, reducing settlement, resist from natural climates such as thawing and freezing and decrease the associated problem with week soil. If we study the previous paper, we find that gypsum is used as a stabilizing agent for expansive soil. The addition of lime and cement will reduce both swell potential and swelling pressure of expansive soil. Volcanic ash, ground natural lime and their combination also used for stabilization. Addition of silica fume also reduces the effect of freezing and thawing. These methods are effective but very costly.

So researchers try to use such method which is cost effective and give more stability. So in recent years engineers try to use different type of fibre as a stabilization agent. Fibres are short discrete material found in market; it will randomly mix with soil. . The main reason of using randomly oriented fibres is to maintain strength isotropy and the lack of potential weak planes that may develop parallel to oriented reinforcement.

2.2 JUTE FIBRE REINFORCED WITH EXPANSIVE SOIL:

Singh *et al* (2013) [42] Studied the effect of Jute fibre in CBR value of soil and it is concluded that as the fibre content increases the CBR value of soil also increases.CBR value of treated soil increases up to 1% of fibre content and after that it will not increased, it means that the optimum value of fibre content was found to be 1%.They also found that the CBR value of soil increases with increases in length and diameter of fibre. Fibre having diameter 2mm and length 90mm the CBR value of reinforced soil Increases up to 200% as compared to untreated soil.

Harshita *et al* (2014) [5] studied the effect of Jute fibre in engineering property of soil like CBR, UCS, OMC and MDD. IT is concluded that as the Fibre content increases Shrinkage limit of soil increases from 8.66% to 14.22%, Optimum moisture content increases from 22.1% to 25.1% and Maximum dry density decreases from 1.61gm/cc to 1.51gm/cc. Jute Fibre also increases the CBR value from 1.8% to 4.1% and Unconfined Compressive Strength increases from 1.09kg/cm^2 to 1.35kg/cm^2. They also concluded that addition of Jute Fibre in Expansive soil decreases its swelling behaviour.

Harshita *et al* (2014) [6] studied the effect of Jute fibre plus lime in engineering property of soil like CBR, OMC and MDD. IT is concluded that as the Fibre lime content increases Shrinkage limit of soil increases from 13.75% to 28.68%, Optimum moisture content increases from 16.20% to 19.60% and Maximum dry density decreases from 1.68gm/cc to 1.58gm/cc. Jute Fibre plus lime also increases the CBR value from 3.10% to 4.95%. They also concluded that addition of Jute Fibre in Expansive soil decreases its swelling behaviour.

Babita Singh *et al* (2014) [43] studied the effect of Jute fibre at optimum value in clay and fly ash-tile waste and it is concluded that the maximum dry density increased slightly and then decreased with increases of fibre content but there is no effect on OMC of mix The strength and permeability characteristics of clayey soil improved on addition of additives used in this study in the appropriate proportions. Soaked and unsoaked CBR values improved considerably for the optimum mixes in comparison to that of locally available clayey soil.

Aggarwal *et al* (2011) [2] studied that the application of Jute fibre improves the sub grade characteristics of soil and it was concluded that the use of Jute fibre reinforcement, reduces the maximum dry density and increases the optimum moisture content of the sub grade soil. They also found that CBR value of the sub grade soil increases up to 250% with the inclusion of bitumen coated with Jute fibre.

Ravishankar and Raghvan (2004) [36] studied the coir fibre reinforcement with laterite soil, they found that as the percentage of fibre increases the OMC, CBR, and tensile strength of the soil increases and MDD value decreases. They also studied that the CBR value increases up to 10% at optimum percentage of the fibre further it will decreases, as the of fibre content increases.

Vishnudas *et al*. (2006) [48] studied the effect of coir- geo-textile reinforcement and it was found that it is cost effective as compared to stone-pitching and other stabilization agent and it is used to protect the slope.

Maher and Ho (1994) [15] studied the effect of paper pulp fibre when it is reinforced with kaolinite clay and it was found that as the percentage of paper pulp fibre increases the peak compressive strength of clay increases.

Prabhakar and Sridhar (2002) [32] studied the strength characteristics and CBR values of the soft soil reinforced with Sisal fibre and It was found that Sisal fibre improve the CBR value, deviator stress and cohesion of the soil.

Manjunath *et al* (2013) [29] studied that when the Jute fibre is reinforced with expansive soil there is substantial improvement in CBR, UCS and compaction characteristics of soil.

Murugesan (2004) [27] studied that for SM-SW type of soil nylon and Jute fibre give good strength and it was found that for nylon fibre CBR value increases up to 96% and for Jute fibre it will increases up to 50%.

Gosavi *et al* (2004) [14] used fibre for the improvement of sub grade properties of expansive soil. They concluded that value of OMC increases and MDD decreases with increase in quantity of woven fabrics in fibreglass.

Maheshwari *et al* (2011) [28] studied that addition of Jute fibre in clayey soil increases the ultimate bearing capacity of the soil and decreases the settlement at ultimate load.

Chauhan *et al*. (2008) [9] Studied the effect of (coir fibre and synthetic fibre) on silty sand used in sub grade with fly ash and they found that both permanent and resilient strains in all material decrease with confining pressure but increase with number of load cycles and deviator stress in reinforced and un-reinforced conditions.

Dey *et al*. (2003) [11] observed that as the percentage of coir fibre increases, the unconfined compressive strength, optimum moisture content of the soil was increases. and Maximum dry density was decreases. It means that UCS, OMC is a direct function with fibre and MDD is an inverse function with fibre.

Rao and Balan (2000) [35] studied that on addition of coir fibre in sand it increases the strength parameter and stiffness of the soil.

Rao et al. (2005) [37] studied that the behaviour of coir fibre similar to synthetic fibre when it is reinforced with sand. The engineering property of the soil can be improve by using low cost material like natural fibre obtained from Jute, coir sisal etc.

Ramesh *et al*, 2010 [39] studied the effect of bitumen coated coir fibre reinforced with expansive soil give marginal variation of UCS value as compared to uncoated fibre when it is reinforced with same soil.

2.3POLYPROPYLENE FIBRE REINFORCED WITH EXPANSIVE SOIL:

H.S Chore *et al* (2011) [10] studied that there is significant increases in the value of CBR as the Fibre content increases up to 1% and further it will not increased. It means that optimum value of Polypropylene fibre to be 1%. The fibres having length 6mm was found to give maximum performance as compared to fibres having 20 mm length. They also observed that OMC increases and MDD decreases as the Fibre content increases in sand-fly ash mix. The soil plane to shear takes more time when it is reinforced with fibre as compared to untreated soil. In Direct shear test angle of friction increases up to 1% fibre content and further it will decreased at the rate of 1.5% fibre content.

Shivanand Mali *et al* (2014) [30] studied the effect of Polypropylene fibre on Shear strength parameter and unconfined compressive strength of soil. It is concluded that shear strength of the Polypropylene fibre reinforced with soil increases up to the fibre content of 0.4%, beyond which it will decreases .As the fibre content increases the cohesion value of soil increases. On the other hand the angle of friction may increases or does not change with fibre content. The UCS value of reinforced soil is more than that of parent soil as the fibre content increases. As the fibre content increases, there is an initial increase the Value of UCS followed by a decrease and the optimum value of fibre content is found to be in the range of 0.2-0.3%.

Mousa F. Attom *et al* (2010) [13] studied two types of fibre (Flat Profile fibre and Crimped profile fibre) and it is concluded that as the fibre content increases the shear strength, angle of internal friction and ductility of sand increases. They also study the effect of aspect ratio on shear strength and angle of internal friction. The increase in aspect ratio increases the shear strength and angle of internal friction.

S.K.Tiwari *et al* (2013) [46] studied the behaviour of Polypropylene fibre on sandy soil and they concluded that the CBR value of soil in soaked and unsoaked condition was improved with increases of Fibre content. For fibre content 0.5%,1%,1.5% and 2.0%, the CBR value under unsoaked condition was observed to be Increased by 47%,70.5% and 111.76% and for soaked condition it will be increased by 53.3%,80.0%,93.33% and 113.3% with respect to the Unreinforced soil. It is also observed there is significant improvement in CBR value of sandy soil when it is reinforced with coir fibre.

Kameshwar Rao Tallapragada *et al* (2009) [38] studied the behaviour of Fibre in Expansive soil. They observed that as the fibre content increases the CBR value also increases but it remains same after 2.25% of fibre content. Also the Nylon thread seems to give better results in terms of CBR as compared to monofilament. There is considerable decrease in cohesion of soil with monofilament whereas it is marginal with nylon thread. Unconfined compressive strength of the soil increases with the addition of both monofilaments and nylon threads, but seems to be better with nylon threads. Swelling pressure of the soil decreases with the addition of both the materials, but there is a marginal difference in change of swelling pressure.

S.Twinkle *et al* (2011) [45] studied the effect of Polypropylene fibre and it is observed that as the fibre content increases, optimum moisture content increases and maximum dry density decreases. In Lime stabilization liquid limit of soil decreases but plastic limit increases. Thus plasticity index of soil also decreases. In UCC, the optimum lime level was noted at 6% lime with a strength increase of about 3.8 times compared to untreated soil for 14 days curing period. The peak UCC value is obtained at 0.75% for all the cases of Polypropylene fibre reinforced soil and Polypropylene plus lime content stabilized soil. In CBR, the optimum lime dosage level was noted at 6% lime with a strength increase of about 3.19 times compared to untreated soil. The CBR value is highest at 0.75% for all the cases of Polypropylene fibre reinforced and Polypropylene plus lime stabilized soil.

Sarkar *et al*. (2012) [41] studied the effect of different sample of pond ash mix with fibre and it was found that up to 3% of fibre content CBR value increase linearly and further it will decreases. Similarly in case of Compaction test, MDD will increase up to 2.5% fibre content and further it will decreases.

Fatani *et al* (1999) [12] studied the effect of Polypropylene fibre reinforced with expansive soil of both aligned and randomly oriented metallic fibres on silty sand and they found that mixing of fibres with silty soil will increase the peak and residual strength from 100% to 300% respectively over the untreated soil.

Ikizler et al. (2009) [4] studied the effect of Polypropylene fibre reinforced with bentonite and it was found that as the percentage of fibre increases, there is decreased the nos. of void in the soil which lead the swell strain behaviour of the soil as compared to untreated soil. Fibre gives strength and stability when it is reinforced with soil.

Chandra *et al*. (2008) [8] **and Singh (2011)** [40] studied the behaviour of Polypropylene fibre in expansive soil. According to the Experimental investigation it was found that the shearing strength of the expansive soil increases when it is reinforced with 20mm length of Polypropylene fibre.

Ziegler *et al.* (1998) [39] studied the effect of short polymeric fibre on crack behaviour of clay subjected to drying and wetting conditions and it was found that on addition of fibre in clayey soil is help us to reduce the crack and increasing the tensile and residual shear strength.

Gosavi et al, (2004) [14],Studied the use of the fibre reinforcement improves the properties of expansive soil which can be used in sub grade and it was found that as the fibre content increases, the CBR of the soil also increases.

Kumar *et al* (2008) [26] studied the effects of Polypropylene fibre reinforcements on conventional parameters of fly ash such as unconfined compression strength, modulus of elasticity, shear strength and C.B.R. They also studied the effect of reinforcements and confinements on permanent strength, resilient strain and resilient modulus of fly ash. Tests were carried out to study the effect of reinforcement on rut depth formation on a model section with simulation of field conditions. Based on the results, it was concluded that fly ash is suitable in sub base, if it is reinforced with Polypropylene fibres.

Al-Wahab & Al-Ourana (1995) [1] studied the effect of Polypropylene fibre when it is reinforced with expansive soil and they found that fibre significantly increases the strength, toughness, durability, ductility, stiffness and energy absorption of the expansive soil.

Nataraj and Mc Manus (1997) [31] studied the effect of fibrillated Polypropylene fibre (25mm) when it is reinforced with clayey soil and it was concluded that as the fibre content increases there is an increase of peak strength, peak friction angle, cohesion and compressive strength but there is no effect on compaction characteristics .

Verma & Char (1978) [47] studied the effect of fibre on the property of the soil, through triaxial test. It was observed that synthetic fibre increases the ductility and angle of internal friction of soil.

Meher and Ho (1994) [15] studied the effect of Polypropylene fibre and glass fibre when it was mix with kaolinite and it was found that fibre has no significant effect on dry density and optimum moisture content .

Tang *et al*. (2007) [44] studied the effect of sand content, on strength of Polypropylene fibre reinforced with clay soil. Polypropylene fibre and glass fibre was mix with kaolinite and it was found that fibre has no significant effect on dry density and optimum moisture content.

Yetimoglu and Salbas (2003) [49] found that shearing strength of the soil was not affected by fibre reinforcement but shearing angle was increased with increase of fibre content.

Puppala and Musenda, (2000) [33] studied the behaviour of Polypropylene fibre of short length (12mm,25mm) and long length (50mm) in expansive soil and they did various experiment like UCS, Consolidation test and it was found that short fibre was more effective as compared to long fibre and reduces swell pressure at considerable extant.

Hoare (1979) [16] found various results of compression and CBR tests on sandy gravel which was reinforced with synthetic fibres 0%- 2% by weight and it was observed that presence of fibres increasing the angle of internal friction and ductility of the soil.

Amin Chegenizadeh *et.al,* (2012) [3] observed that plastic fibre increasing the bearing capacity of soil in comparison to natural fibre at fibre content of 0.6%.

Ranjan *et. al* , (1996) [34]**, Charan, (1995)** [7] studied the effect of fibre in clay soil and according to their study they found that as the percentage of fibre increases all the engineering property of the soil was improved.

According to the study of various journals, I found that natural and synthetic fibre reinforcement is effective for soil stabilization. I studied various type of synthetic and natural fibre like glass fibre, cord waste fibre, Polypropylene fibre, sisal fibre ,coir fibre, Jute fibre, pulp fibre in different area like slope, embankment, retaining wall, sub grade soil, foundation soil, I found that all the engineering property of the soil like optimum moisture content, maximum dry density, California, bearing ratio, unconfined compressive strength, Direct shear test, swelling potential and free swell index of the soil was improved. I found that bearing capacity and shearing strength of soil increases, as the fibre content increases. Basically according to the journals I understood that the fibre fills the void of soil and absorb moisture from the soil. Fibre works like reinforcement with soil and it absorb moisture from the soil and reduce its free swell index. Basically fibre increases the strength of soil. We all know that soil week in tension, so when the fibre is mixed with soil, it was found that it increases the tensile strength of the soil. Geo-textile sheet was used to protect the slope, retaining structure but in modern year the use of fibre give much importance to soil. After studying the various results of numerous researchers, I chose the randomly oriented Jute fibre and Polypropylene fibre with expansive soil in order to improve the property of soil.

CHAPRER-3

EXPERIMENTAL INVESTIGATION

3.1 INTRODUCTION:

Jute Fibre and polypropylene fibre are found in India in large scale. These materials are used to solve the various geotechnical problems. So, I am using such type of material for the stabilization of soil. Experimental investigation and physical property of the fibre are discussed in this chapter.

3.2 Material used:

3.2.1 Expansive soil:

The expansive soils used in the study were collected from depths between 0.3-1.0m below ground level from District Morena Madhya Pradesh.

The physical appearance of this soil is:

(1). Black or darkish grey to brown colour

(2).Shrinkage and swelling behaviour when it contact with moisture condition

(3). Crack and heave formed and the cracks width are 15-20 cm.

3.2.2 Jute fibre:

Jute fibre is collected from the CHANDRA PRAKASH AND COMPANY JAIPUR. The following physical property of Jute Fibre is provided by Company are:

Table.1: Physical Property of Jute Fibre:

S.No	Property	Value
1	Fibre length	12 mm
2	Ultimate diameter	0.015-0.020 mm
3	Colour	Golden, yellow brown
4	Strength (Tenacity)	3-4 gm/den
5	Elongation	1.7% at break
6	Specific gravity	1.5
7	Moisture regain	13.75%
8	Resiliency	Bad
9	Dimensional stability	Good

10	Abrasion resistance	Average
11	Effect of light and heat	Average
12	Effect of microorganism	good

3.2.3 Polypropylene Fibre

Polypropylene fibre is collected from DELHI BUILDING STORE, NEW DELHI. The following physical property of the polypropylene fibre are given below in table

Table.2: Physical Property of the Polypropylene Fibre:

S.No	Property	Value
1	Material	Virgin Polypropylene
2	Form	Monofilament fibre
3	Specific gravity	0.91
4	Tensile strength	450-560Mpa
5	Length	12mm
6	Colour	White
7	Acid/Alkali resistance	Excellent
8	Young’s modulus	3450 Mpa
9	Dispersion	good
10	Average diameter	0.034mm
11	Fusion point	165°c

3.3 SAMPLE PREPRATION:

In this report I used two types of fibre for the stabilization of expansive soil. One is Polypropylene fibre and other is Jute fibre. I adopted different values of fibre content for present study and the values for both fibres were 0.25%, 0.50%, 0.75%, 1.0%, 1.25% and 1.5% by weight of expansive soil. The mixing of both fibres beyond the 1.5% is very difficult, so I decided to stop it with 1.5% of fibre content. The mixing of the fibre is very difficult in soil. When the fibre mixed in dry state of soil it will segregate and there is no proper mixing of fibre in soil. So fibre were added in moist soil at different percentage and were tested as per IS specification. All the mixing was done manually and continued it till it became homogeneous mixture. This is the methodology used to study the effect of fibre on soil.

Fig.4: Fibre mix in Expansive Soil

Table.3: Methodology used for stabilization of expansive soil using Jute fibre and Polypropylene Fibre

S.No	Test method	Complying standards	Sample variables taken Individually		Parameter
			Jute fibre	Polypropylene fibre	
1	Standard Proctor Test	IS:2720(Part-VII)-1987 and (Part VIII)-1987	0.25%, 0.50%, 0.75%, 1.00%, 1.25%, 1.50%	0.25%, 0.50%, 0.75%, 1.00%, 1.25%, 1.50%	OMC,MDD
2	UCS Test	IS:2720(Part-X)-1991	0.25%, 0.50%, 0.75%, 1.00%, 1.25%, 1.50%	0.25%, 0.50%, 0.75%, 1.00%, 1.25%, 1.50%	UCS

3	CBR Test	IS:2720(Part-XVI)-1987	0.25%, 0.50%, 0.75%, 1.00%, 1.25%, 1.50%	0.25%, 0.50%, 0.75%, 1.00%, 1.25%, 1.50%	CBR
4	Direct Shear Test	IS:2720(Part 11)-(1983)	0.25%, 0.50%, 0.75%, 1.00%, 1.25%, 1.50%	0.25%, 0.50%, 0.75%, 1.00%, 1.25%, 1.50%	Shear strength, Cohesion, Angle of internal friction

3.4DTETERMINATION OF PARTICLE SIZE DISTRIBUTION IS: 2720 (PART IV) (1985)

3.4.1 Sieve analysis, IS: 2386 (Part I)(1963).

The sieve analysis is used to determine the particle size distribution of the soil having particle size >= 0.075mm. For coarse grained soil generally sieve analysis is used (dry/wet sieve). In dry sieve analysis a set of IS sieve is arranged and find out the Percentage of finer corresponding to the IS sieve. The result concluded from sieve analysis is plotted on semi-log graph. In semi log graph abscissa shows the particle size and ordinate shows the percentage of finer. From graph we find out the value of D_{10}, D_{30}, and D_{60}. Which gives the value of coefficient of curvature and coefficient of uniformity which tell us about the range of the particle?

3.4.2Hydrometer analysis: IS: 2386 (Part I)(1963).:

The hydrometer analysis is used to determine the particle size distribution of the soil having size 0.075mm to 0.01mm .It means that hydrometer is used to find out the particle range of fine grained soil. The principal of hydrometer analysis to obtained the clay fraction. Like sieve analysis similar data sheet is presented on semi-log graph and find out the particle size of the soil. Hydrometer analysis have identify the particle size< 0.02mm. This test is done when more than 20% of soil passes through 0.075mm

Sieve and 90% or more passes through 4.75mm sieve. The hydrometer analysis based on stokes's law. The formula for calculating the particle size is

Particle size $D = Mx\sqrt{He/t}$

Where $M = 1.33x10^{-3}$

H_e=height of hydrometer

T= time elapsed in min.

3.5 DETERMINTION OF INDEX PROPERTY OF SOIL

3.5.1 Specific gravity IS: 2720(Part1V) (1985)

The specific gravity is defined as the density of given substance to the density of water. Specific gravity of the soil is calculated in lab by using pycnometer and hydrometer analysis method and its significance is used to study the phase relationship of air, water, and solids in a given volume of the soil. It is also used to calculate the void ratio and degree of saturation of soil.

The formula for the calculation of specific gravity is.

The specific gravity of the soil= $(W_2 - W_1)/ [(W_2 - W_1)-(W_3-W_4)]$

Where W_1= weight of empty bottle in gm

W_2= weight of pycnometer + oven dry soil

W_3= weight of pycnometer + oven dry soil+ water

W_4= weight of pycnometer + water full

The precaution should be adopted during experiment is that the soil whose specific gravity measure is completely dry.

Table.4: Range of Specific Gravity

S.No.	Soil type	Range of specific gravity
1	Sand	2.63-2.67
2	Silt	2.65-2.7
3	Clay& silty clay	2.67-2.9
4	Organic soil	<2.0

3.5.2 Liquid limit IS: 2720(Part V) (1985)

The liquid limit is defined as water content at which the behavior of clayey soil changes from plastic state to liquid state as per IS specification. The Casagrande's apparatus was used to determine the liquid limit of the soil. Soil is placed in metal cup and groove is made down its centre with tool having bottom width 2mm, top width 11mm and height is 8mm. The cup is repeatedly dropped 1cm on to the hard base at the rate of 120 blows per min, during which the groves closes with each other. The nos. of blows is recorded and the moisture content is calculated at which the groves close with each other. Now the data is presented on semi-log graph in which the abscissa shows no of blows and ordinate shows water content. The moisture content at which it takes 25 nos. of blows is defined as liquid limit.

3.5.3 Plastic limit IS: 2720(Part V) (1985)

The plastic limit is defined as the moisture content where the thread breaks apart at a diameter of 3.2mm.It is determined by rolling out a thread of a fine portion of soil on flat surface. In the beginning of the rolling thread retain its shape to very narrow diameter and further when the moisture content decreases due to evaporation, then thread will begin to break apart, such state is called plastic state of soil and it is called plastic limit of soil.

3.5.4 Plasticity index: 2720(Part V) (1985)

The plasticity index is calculated from liquid limit and plastic limit of the soil and it is defined as the difference between the liquid limit and plastic limit of the soil.

$$I_p = W_L - W_P$$

W_L= Liquid limit , W_P = plastic limit

Table.5: Group Symbol in Plasticity Chart: IS: 1498-1970)

S.No	Group symbol	Typical name
1	CL	Clay with low plasticity
2	CI	Clay with intermediate plasticity
3	CH	Clay with high plasticity

4	ML	Silt with low plasticity
5	OL	Organic silt
6	MI	Intermediate silt
7	OI	Organic silt
8	MH	Silt of high plasticity

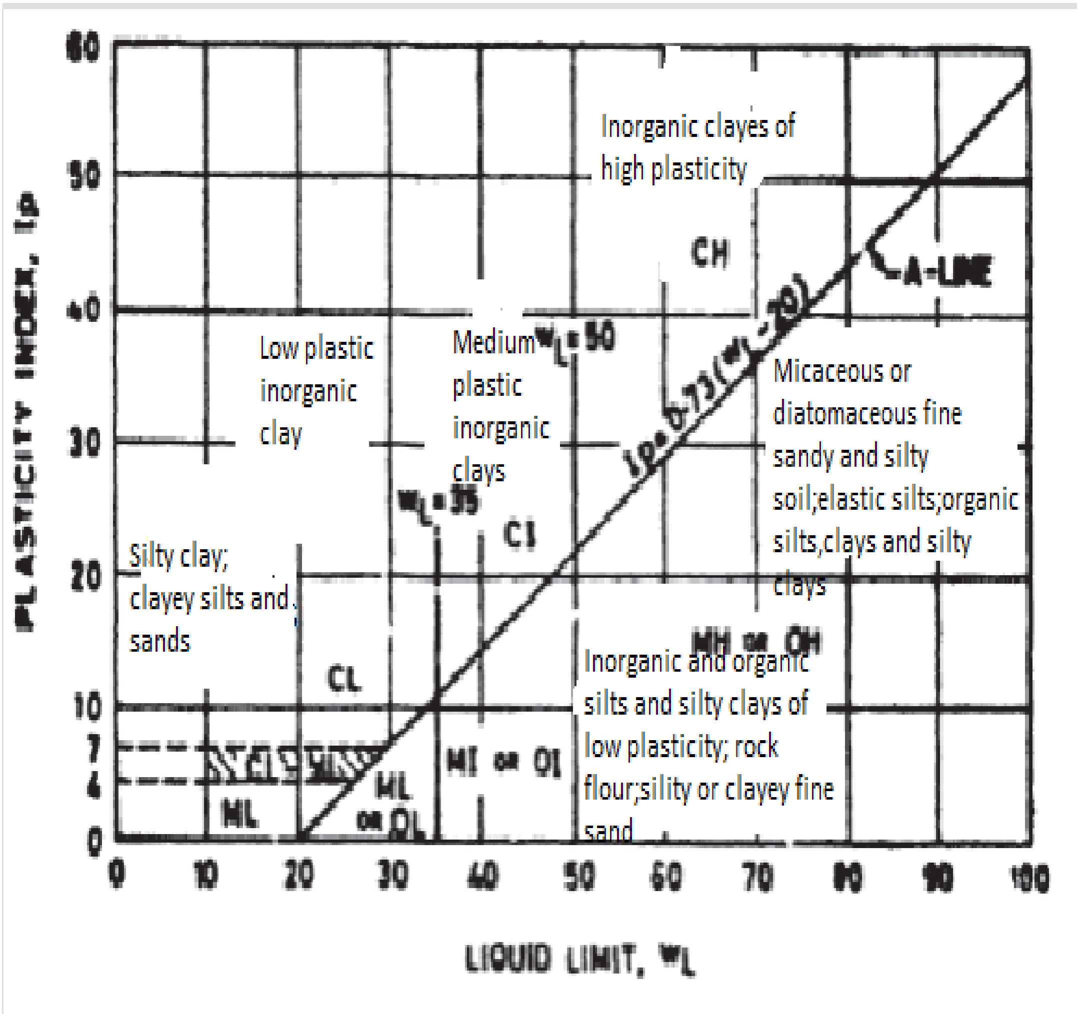

Fig.5: Plasticity Chart (IS: 1498-1970)

3.5.5 Free swell index, IS: 2720 (part XL) (1977)

Free Swell Index is the increase in volume of a soil, without any external constraints, on submergence in water. Free swell index test is used to study the expansive behaviour of the soil. The determination of free swell index by using following procedure. Take two specimens of oven-dry soil each weigh 10gm, passes through 425µm IS sieve. Pour each soil specimen into graduated cylinder of 1000ml capacity and one cylinder is filled with water and other is filled with kerosene up to 100ml. Remove the entrapped air by gently shaking with glass rod. Now allow it to state of equilibrium for 24hours. After 24 hours the final volume of soil in each sample read out. The free swell index can be finding out by using following formula.

$$\text{Free swell index } (\%) = (V_d - V_k)/V_k \times 100$$

Where,

V_d= volume of soil specimen read from graduated cylinder containing distilled water.
V_k = volume of soil specimen read from the graduated cylinder containing kerosene.

Table.6: Free Swell Index & Degree of Expansiveness

S.No	**Free swell index**	**Degree of Expansiveness**
1	<20	Low
2	20-35	Moderate
3	35-50	High
4	>50	Very high

3.5.6 Electronic Dispersive Spectrum (EDS):

EDS uses the X-ray spectrum emitted by a sample is bombarded with a fixed focused beam of electrons localized chemical analysis. All elements of atomic number 4 (Ser) to 92 (U) can be detected in principle, but they are not equipped for all instruments elements "Light" (z <10). Qualitative analysis involves the identification of the lines in the spectrum and is very easy due to the simplicity of the spectra of X-ray quantitative analysis (determination of the concentrations of the elements) involves measuring line intensities for each element in the sample and for the same elements in the calibration standards known composition. By scanning the beam in a manner similar to a television display screen and the intensity of selected Line X-ray images of element distribution or "maps" can be produced. Also, that by Electrons collected sample reveal the surface topography or the average atomic number varies depending on the selected mode. The scanning electron microscope (SEM), which closely related to the probe of electrons, it is primarily designed for producing images of electrons but Also for mapping elements even point analysis as X-ray spectrometer, is added. There is considerable overlap in the functions of these instruments.

3.5.7 Scanning electron microscope (SEM):

The scanning electron microscope (SEM) is one of the most versatile instruments available for the examination and analysis of the microstructure, morphology, chemical composition characterizations and electrical conductivity of the soil. It is a type of electron microscope that images the surface of soil specimen by scanning it with high energy beam of electron, this high energy beam electron generate a variety of signals at the surface of soil specimen. The signals that drive electron-sample interactions reveal information about the sample including external texture, chemical composition, and crystalline structure and orientation of materials. Areas ranging from 1 cm to 5 microns in width can be imaged in a scanning mode, using conventional SEM techniques and the range of magnification of these techniques from 20X to 30,000X and the range of spatial resolution from 50 to 100 nm. The SEM is also used to analyses the selected point, locations on the sample and this approach is especially useful in studying qualitatively or semi-quantitatively determining chemical compositions (using EDS), crystalline structure, and crystal orientations (using EBSD).

Secondary electron and back scattered electron is the types of signals that is produced by Scanning electron microscope. Basically we have use the primary signals for scanning the topography of the structure for the visualization of surface texture and roughness, but in the inclusion of secondary signals it contrast the images of the topography, according to which we can visualize the texture , roughness in large scale. The topographical image is dependent on how many of the secondary electrons actually reach the detector. A secondary electron signal can resolve surface structures down to the order of 10 nm or better. Although an equivalent number of secondary electrons might be produced as a result of the specimen primary beam interaction, only those that can reach the detector will contribute to the ultimate image of soil specimen. Back scanning electron is another method to produce image. A BSE is defined as one which has undergone a single or multiple scattering events with energy greater than 50eV. The elastic collision between the electron and specimen bounce back the electron with great energy. About 10-50% of beam electron scattered back and 60-80% retained. So these backscattered beams contrast the image of specimen.

But according to the study of the various researchers they find out that secondary electron is give better result as compared to the back scattering electron signals in SEM. SEM method is very useful when the soil specimen in bulk.

3.6 DETERMINATION OF ENGINEERING PROPERTY OF THE SOIL:

3.6.1 Proctor compaction test: IS: 10074(1982)

The standard compaction test gives the relationship between dry density and the moisture content. Compaction is one kind of densification that is realized by rearrangement of expansive soil particles with fibre at different percentage without outflow of water. The Experimental set up is consist of .1) Cylindrical mould having internal diameter 101.6mm and internal height 116.43mm. 2) Detachable base plate. 3) Collar having diameter 114.3mm. 4) The weight of the rammer is 2.5kg, nos. of blow at each three layer is 25 and the height is 304.8mm. As the water content increases the bulk density of the soil increases because compaction effort removes all the air from the compacted soil. But at particular water content it will fall, at that water content we will stop the experiment. Graph is plotted between water content (abscissa) and dry density (ordinate). According To graph we will find out the maximum dry density at optimum moisture content. The equation used in the following experiment.

$$Bulk\ density = \frac{mass\ of\ compacted\ soil(gm)}{volume\ of\ mould(cc)}$$

$$Moisture\ content = \frac{mass\ of\ water(gm)}{mass\ of\ soil(gm)} X\ 100$$

$$Dry\ density = \frac{Bulk\ density}{1 + \frac{moisture\ content}{100}}$$

3.6.2Unconfined compressive test IS: 2720(Part 10) (1987):

The unconfined compressive test is used to study the compression behavior of the soil. The samples is prepared at different percentage of fibre content with expansive soil at different optimum moisture content and place it for curing period for different days. Now the sample is placed under the compressive cylinder. The load dial gauge is attached to compressive cylinder. The load dial reading was taken corresponding to every strain dial gauge reading The unconfined compressive load of the sample is that value at which load dial gauge reading is const or fall as we increase the compressive load. The use of the strain dial gauge reading is to find out the corrected area i.e. A =A (1-ε). This corrected area is divided by load give the unconfined compressive strength. This unconfined compressive strength is used to calculate the undrained shear strength.

$$Unconfined\ compressive\ strength(qu) = \frac{Unconfined\ load(KN)}{Corrected\ area(m2)}$$

Where,

Corrected area=cross-sectional area/ (1-ε).

$$\varepsilon = \frac{change\ in\ length(\nabla l)}{orignal\ length(l)}$$

3.6.3California bearing ratio test, IS: 2720(Part 1)(1987):

The California bearing ratio test is penetration test meant for the evaluation of sub grade strength of roads and pavements. The results obtained by these tests are used with the empirical curves to determine the thickness of pavement and its component layers. This is the most widely used method for the designing of flexible pavement and determines the CBR value of undisturbed and remoulded soil in both, soaked and unsoaked condition. The experimental set up consist of .1) Cylindrical mould with inside dia. 150 mm and height 175 mm, provided with a detachable extension collar 50 mm height and a detachable perforated base plate 10 mm thick. 2) Spacer disc 148 mm in dia. and 47.7 mm in height along with handle. **3)** Weight of hammer is 2.6 kg with a drop of 310 mm.4) The annular surcharge weight of metal is 2.5 kg each, 147 mm in dia., with a central hole 53 mm in diameter. The test consists of cylindrical plunger 50mm in dia. and 100 mm in length is penetrating in mould at the rate of 1.25mm/min. The load is recorded corresponding to 2.5mm and 5.0mm. Now by drawing the load penetration curve find the value of load at 2.5mm and 5.0mm and recorded higher value of both penetration. Generally 2.5mm give higher value.

Proving ring const. for load dial gauge, 1Div=4.518kg=45.18N

Proving ring const for penetration dial gauge, 1Div=0.01mm

$$CBR(\%) = \frac{Test\ load(N)}{Standard\ load(N)} X\ 100$$

Table.7: Standard Load for CBR Test

S.No	Penetration of plunger(mm)	Standard load(Kg)
1	2.5	1370
2	5.0	2055
3	7.5	2630
4	10	3180
5	12.5	3600

3.6.4 Indirect tensile strength test (Brazilian test), IS: 10082(1982):

Brazilian test is used to study the indirect tensile strength of the rocks and soil specimen. Prepare a soil specimen with different percentage of fibre content having L/D ratio is 2. The specimen is placed centrally in both upper disc and lower disc. Upper disc placed carefully on specimen so that there are no cracks formed in it. The lower disc move up slowly when we apply the load by pumping. Due to compression the cracks formed in specimen, in first crack record the reading of load and observe the pattern of cracks. The following formula used to calculate the tensile strength of soil.

Proving ring const. for load dial gauge reading is 1Div. = 1KN

$$T = \frac{2P}{\pi DL}$$

Where,

T=tensile strength (KN/m^2)

P= maximum compressive load (KN)

D= diameter of sample (m)

L= length of sample (m)

3.6.5 Direct shear test, IS: 2720(Part 11) (1983):

In many engineering problems such as design of foundation, retaining walls, slab bridges, pipes, sheet piling, the value of the angle of internal friction and cohesion of the soil play an important role. Direct shear test is used to predict these parameters quickly. The test can be carried out at different moisture contents, before running the test, the sample must be saturated with water. To find the reliable results, the test is often carried out on three or four samples of undisturbed soil. The soil sample is placed in a cubic shear box having dimensions 6cm X 6cmX 3cm composed of a upper and lower box. The limit between the two parts of the box is approximately at the mid height of the sample. The sample is subjected to a controlled normal stress and the upper part of the sample is pulled laterally at a controlled strain rate or until the sample fails. The applied lateral load and the induced strain are recorded at given internals. These induced strains are used to find out the corrected area. Now divide the corrected area to the applied load will give shearing stress. Plot the graph between shearing stress and horizontal shear displacement. Record the maximum value of shearing stress at each value of normal stress. Plot the graph between shearing stress (ordinate) and normal stress (abscises). A linear curve fitting is often made on the test result points. The intercept of this line with the vertical axis gives the cohesion and its slope gives the peak friction angle. The formula used to find out the value of shearing stress is:

$$Shearing\ stress(KN/m2) = \frac{Shearing\ load(KN)}{Corrected\ area(m2)}$$

CHAPTER -4

RESULT AND DISCUSSION

4.1PHYSICAL PROPERTY OF THE EXPANSIVE SOIL:

4.1.1Grain size distribution, 2720(part IV) (1985):

An Extensive investigation carried on expansive soil. Based on sieve analysis, it was found that more than 50% of soil passes through 0.075mm sieve and it can be classified as fine grained soil. I also found that the liquid limit of the soil is greater than 50%. Thus the Soil categorized above can be either MH or CH. Plasticity chart also helps to classify the soil. According to this, it was found that the plasticity index of the soil is 33.25%. And it can be safely classified as CH i.e. Clay of high plasticity.

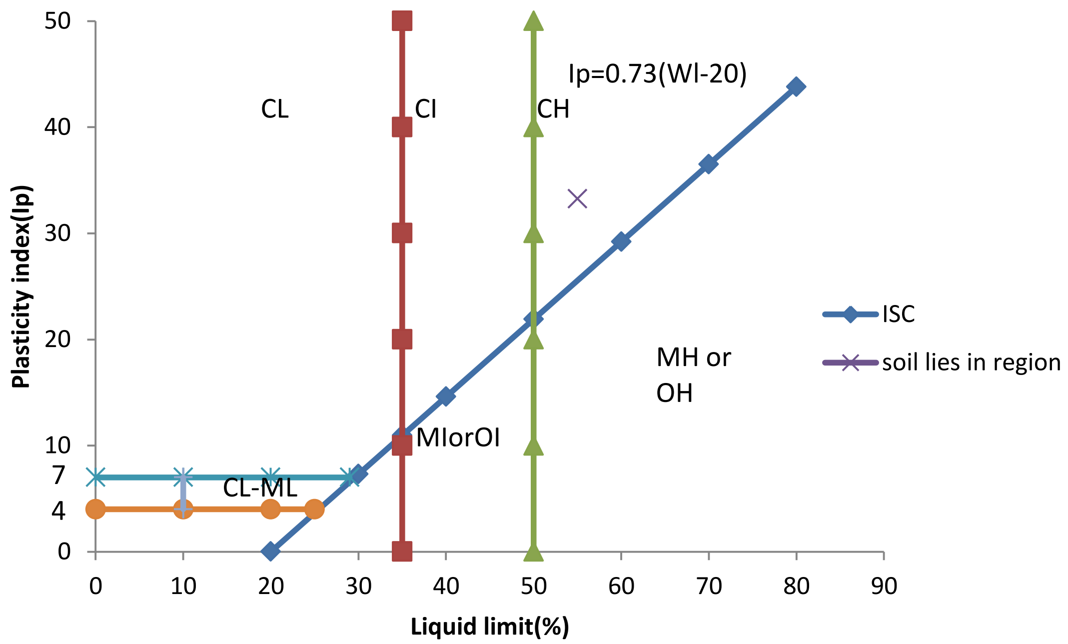

Fig.6: Plasticity Chart

Based on the particle size distribution fig,7, I graded the soil in to different category that is Percent Gravel(>4.75mm)=100- 100=0%, Percent Coarse sand(4.75-2mm)= 100- 100=0% , Percent medium sand(2-0.425mm) =100-97= 3.00% , Percent of fine sand (0.425-0.075mm) =97- 92=7.00%,Percent of silt/clay(<0.075mm)=92%

As we know that if the percentage of the silt and clay fraction is greater than 12 percent, then it is required for us to determine the fine grain fraction size to assess the

Percentage of the clay particles and silt particles which can be determined by hydrometer analysis.

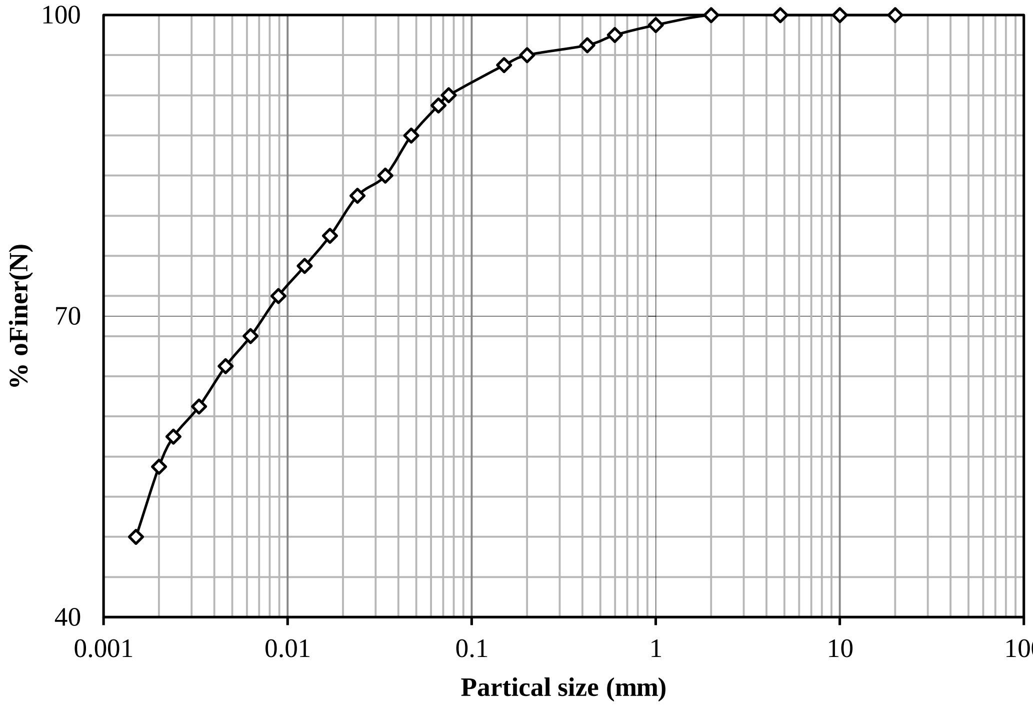

Fig.7: Particle Size Distribution

Based on the hydrometer analysis fig,8, I graded the fine grained soil in different category that is, Percent coarse silt (0.063-0.02mm) =10%, Percent medium silt (0.02-0.0063mm) =12%, Fine silt (0.063-0.002), =13%, Clay (<0.002) =48%. According to hydrometer analysis it was found that expansive soil is clay with some percentage of silt fraction.

Fig.8: Arrangement of sieve

4.1.2 Specific gravity IS: 2720(Part1V) (1985):

The Specific gravity of expansive soil is determined by IS: 2720 (Part 1V section 1 (1985) and It is found to be 2.69. For clayey and silty soil the range of specific gravity is 2.67-2.9.

The application of specific gravity in geotechnical engineering is used to study the types of soil and to calculate the void ratio and degree of saturation. The specific gravity of the expansive soil is very high, due to this it has more porous and have voider ratio. Due to the high void ratio it cannot control the water through it and failure of structure.

If we use fibre in soil it fills the void and decreases the void ratio and specific gravity of soil, this factor increases the strength of soil. Due to such variation of specific gravity, we can use this use in embankment, slope, and retaining wall.

4.1.3 Liquid limit IS: 2720(Part V) (1985):

The liquid limit of the soil is determined by IS:2720 (Part V section 1 (1985).According to the experimental result it is found that the liquid limit of the soil is 55% which is greater than 50% , so soil is classified as Expansive soil. The range of liquid limit for Expansive soil is 50-100%.

Liquid limit is an important physical property. The application of liquid limit in geotechnical engineering is used to classify soil, correlate various soil properties with strength, estimate swelling potential of soil, and hundreds of similar uses in geotechnical engineering.

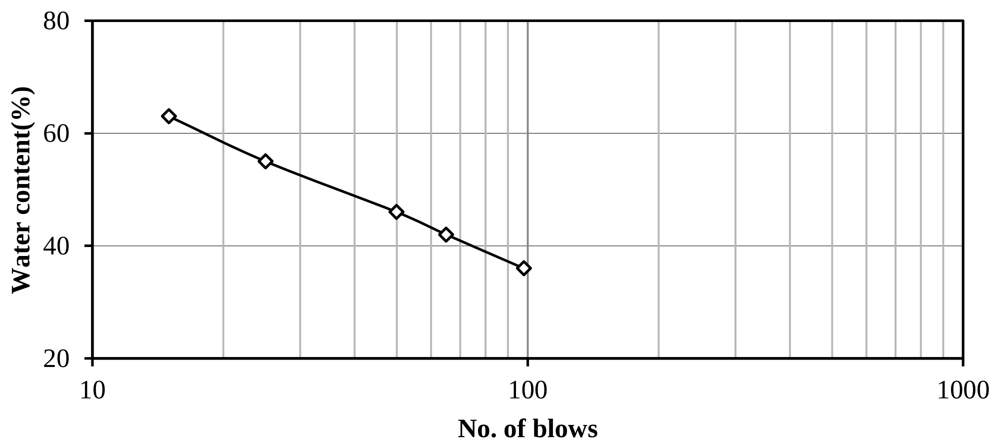

Fig.9: Variation of Water Content with No of Blows of soil

4.1.4 Plastic limit IS: 2720(Part V) (1985):

Plastic limit of the soil is determined by IS specification. According to the experimental result it was found that the plastic limit of the soil is 21.75%. The range of plastic limit for expansive soil is 20-65%.

The application of plastic limit in geotechnical engineering is to find out the plasticity index of soil.

4.1.5 Plasticity index: 2720(Part V) (1985)

The plasticity index is defined as the difference between the liquid limit and plastic limit of the soil and it was found that the plasticity index of expansive soil is 33.25% which is very high.The application of plasticity index in geotechnical engineering is used to classify the soil which lies either above A-line or below A-line by using plasticity chart. A plasticity index lower than 20 to 24 was generally a safe area but if it is higher than this value respond to swelling behavior of clay.

4.1.6 Free swell index, IS: 2720 (part XL) (1977):

The free swell index is determined by IS specification. According to the experimental result it was found that free swell index of the soil is 55% which is greater than 50%. If we study the expansive range of soil then I found that this soil is very expansive in nature.

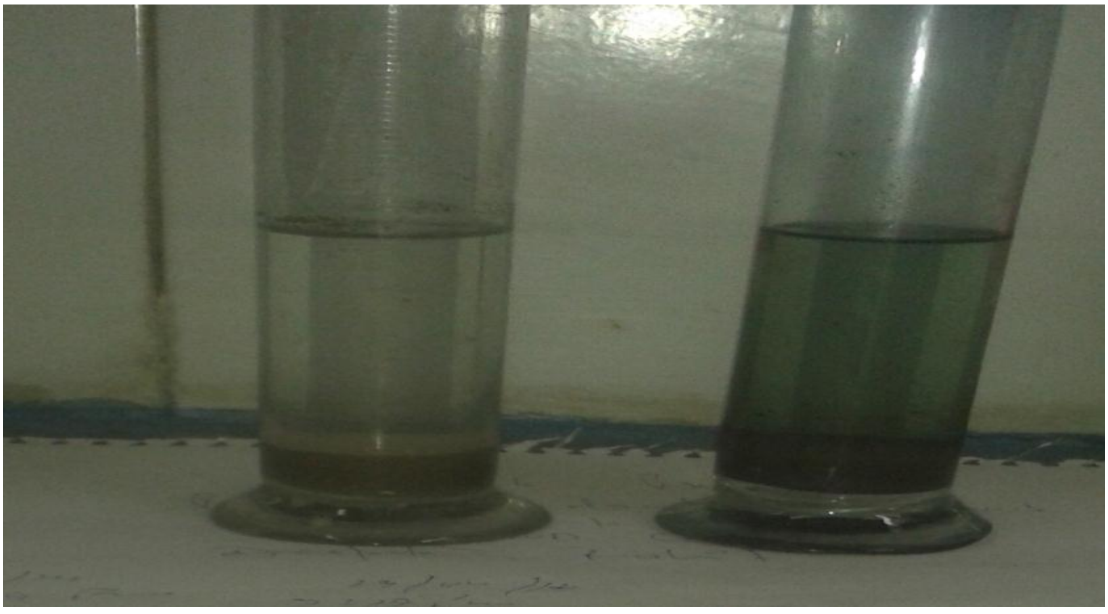

Fig.10: Free Swell Index of Soil

The application of free swell index in geotechnical engineering is to determine the swelling behavior of soil because most of the structure like road, dam, embankment, canals fails due to the swelling and shrinkage behavior of soil. So the study of swelling behavior of the soil before constructing such type of structure is very important.

4.1.7 **Electronic Dispersive Spectrum (EDS):**

Mineral identification is based on d-spacing and relative peak intensities. All minerals generate multiple diffraction peaks. When I analysed the EDS pattern of expansive soil, then I found that it is composed of different types of minerals. Each mineral has its individual peaks. EDS pattern present a challenge in minerals identification. EDS segregate the soil particle into different size Even XRD identify the minerals of small fraction. So XRD is an innovative technique to identify the mineralogy in a given soil as compared to EDS.

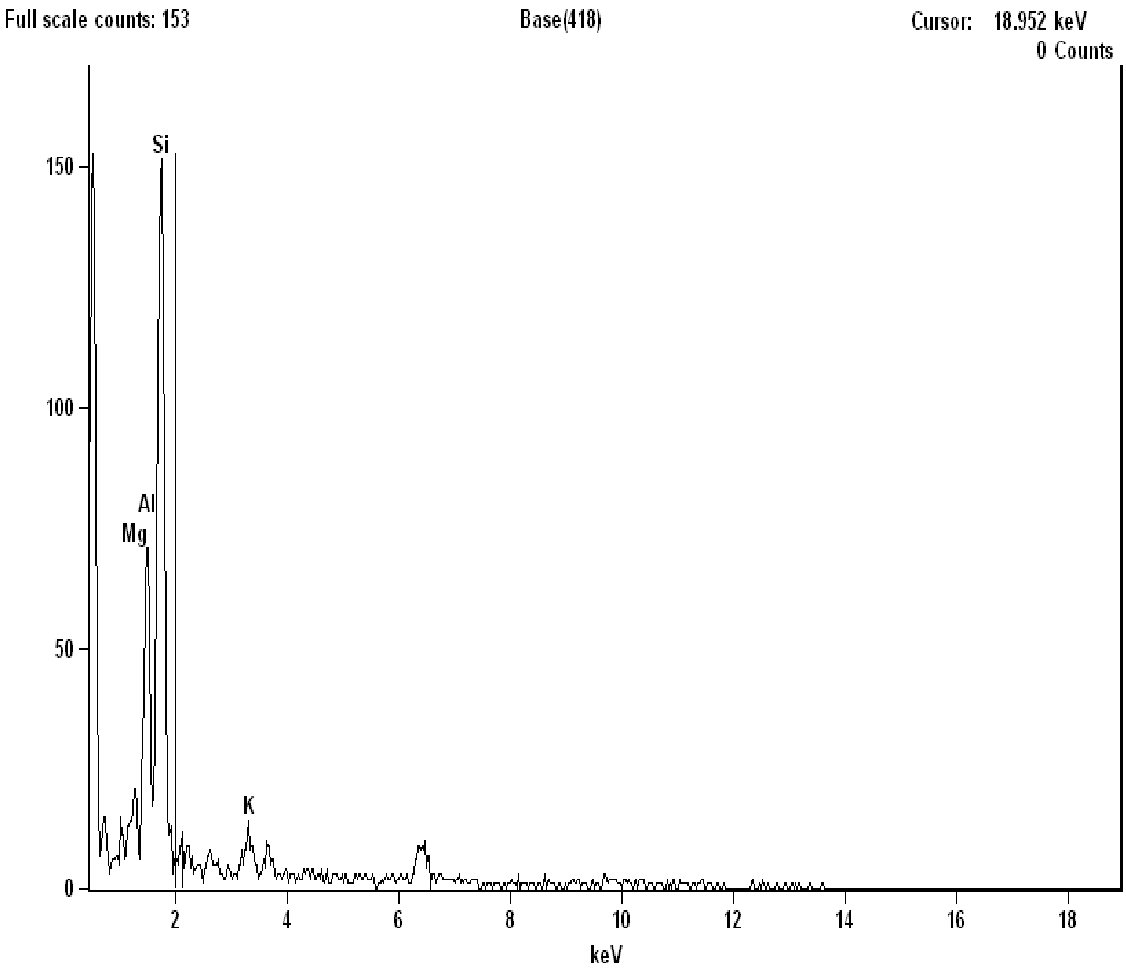

Fig.11: Electronic Dispersive Spectrum of Soil

Table.8: Mineralogical Characteristics of Soil

Acc.Voltage: 15.0 kV Take Off Angle: 78.2 deg. Quantitative Results for: Base (418)

Element Line	Net Counts	Int. Cps/nA	Weight %	Weight % Error	Atom %	Atom % Error	Formula	Standard Name
Mg K	94	---	2.96	+/- 0.50	3.47	+/- 0.59	Mg	
Al K	628	---	19.90	+/- 1.43	20.98	+/- 1.50	Al	
Si K	1750	---	68.15	+/- 2.26	69.02	+/- 2.29	Si	
Si L	0	---	---	---	---	---		
K K	130	---	8.98	+/- 1.73	6.54	+/- 1.26	K	
K L	0	---	---	---	---	---		
T otal			100.00		100.00			

Fig.12: Coating Apparatus at Nano. Tech. Lab

Fig.13: Installation of Sample

4.1.8 Scanning electron microscope (SEM):

Scanning electron microscope gives the information about the morphology of the sample particle. I analysed the various sample in pictorial form by SEM method. In fig.15&16 I analysed the expansive soil at 10um and 20um scale. I found that the soil sample is composed of tiny and big particle. The soil has large surface area. I also saw that, the voids in between the soil particle are in excess amount.

In fig.17&18 I also analysed the Jute fibre by SEM method at 100um and 50um scale. I found that the surface of the Jute fibre is rough and the white spots in this fibre tell us about the composition by which this fibre is produced. The diameter of the Jute fibre is 56.1um.This dia. is helpful to find the aspect ratio i.e. 213.9

Fig.14: SEM Apparatus in our Nano. Lab

In fig.19&20 I analysed the Polypropylene fibre at 100um and 300um scale. I found that the surface of the Polypropylene fibre is smooth and the diameter of this fibre is 51.6um. This fibre is helpful to fill up the void of the soil. The aspect ratio of this fibre is 232.1

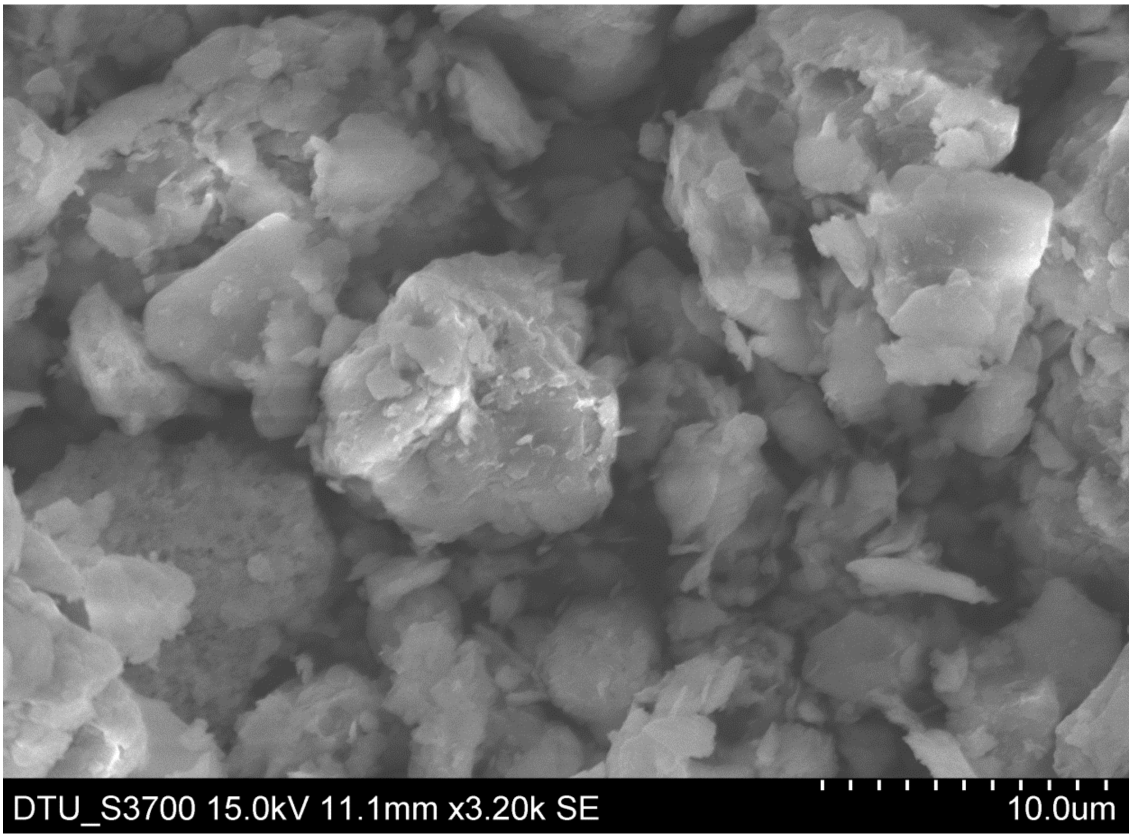

Fig.15: Expansive Soil at 10.0um Scale

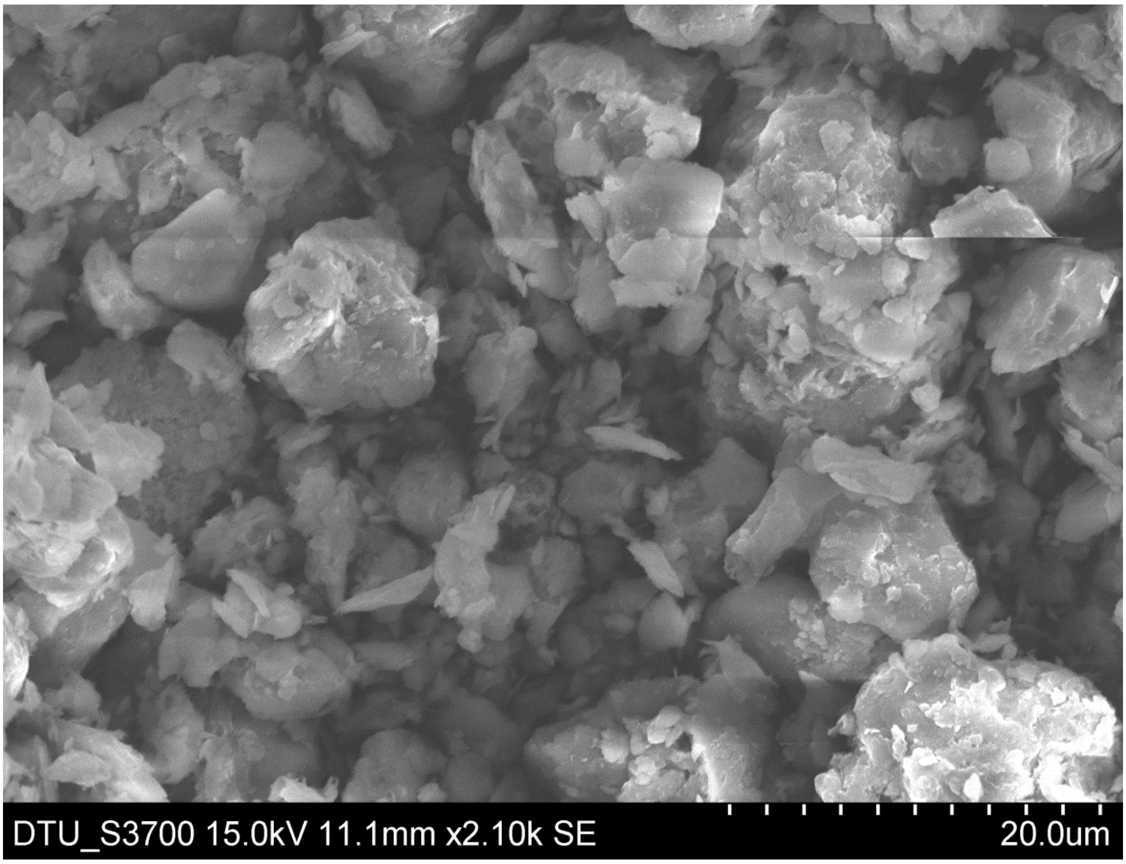

Fig.16: Expansive Soil at 20.0um Scale

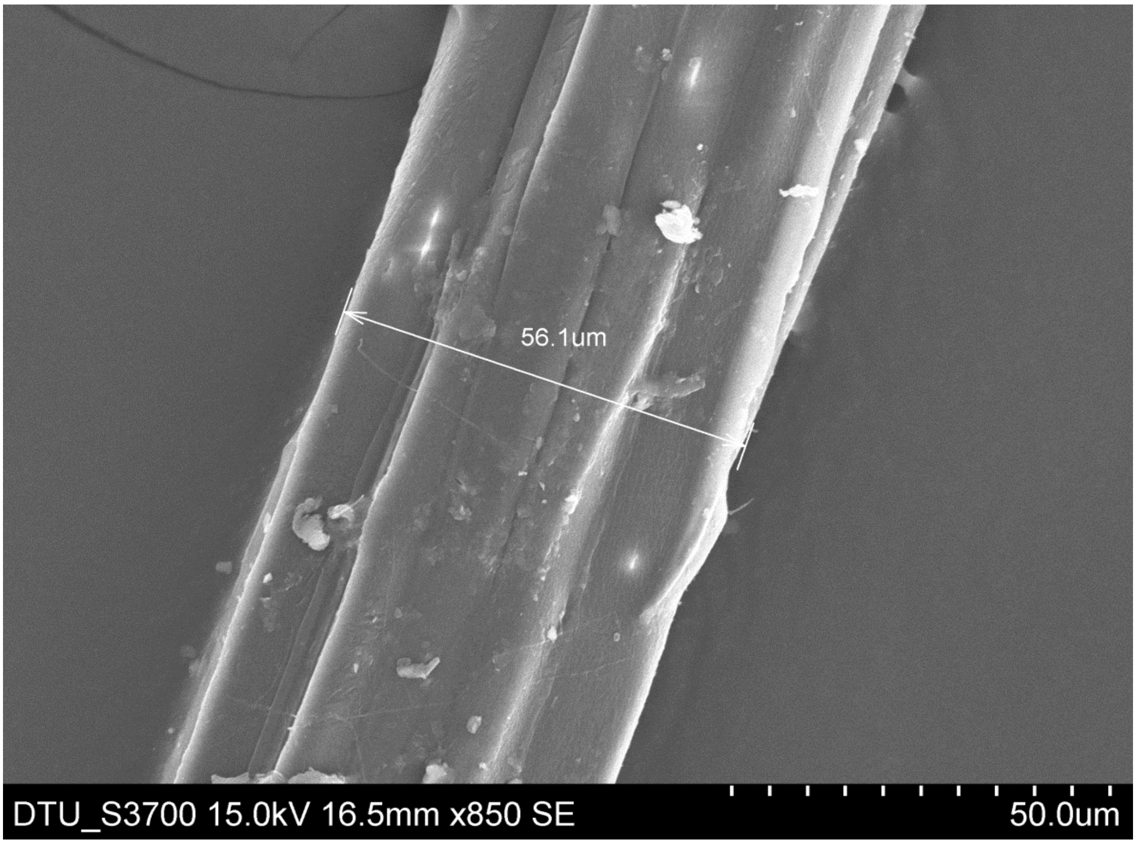

Fig.17: Jute Fibre at 50.0um scale (Aspect ratio=213.9)

Fig.18: Jute Fibre at 100um scale

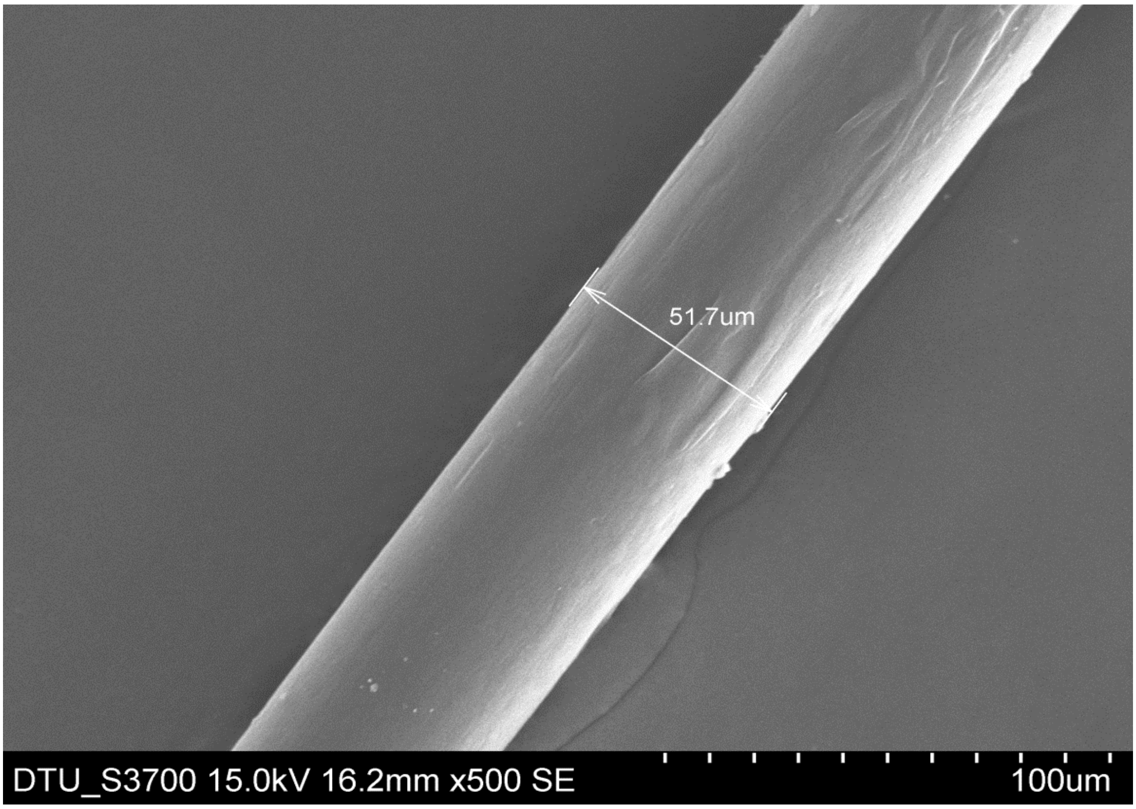

Fig.19: Polypropylene Fibre at 100um Scale (Aspect ratio=232.1)

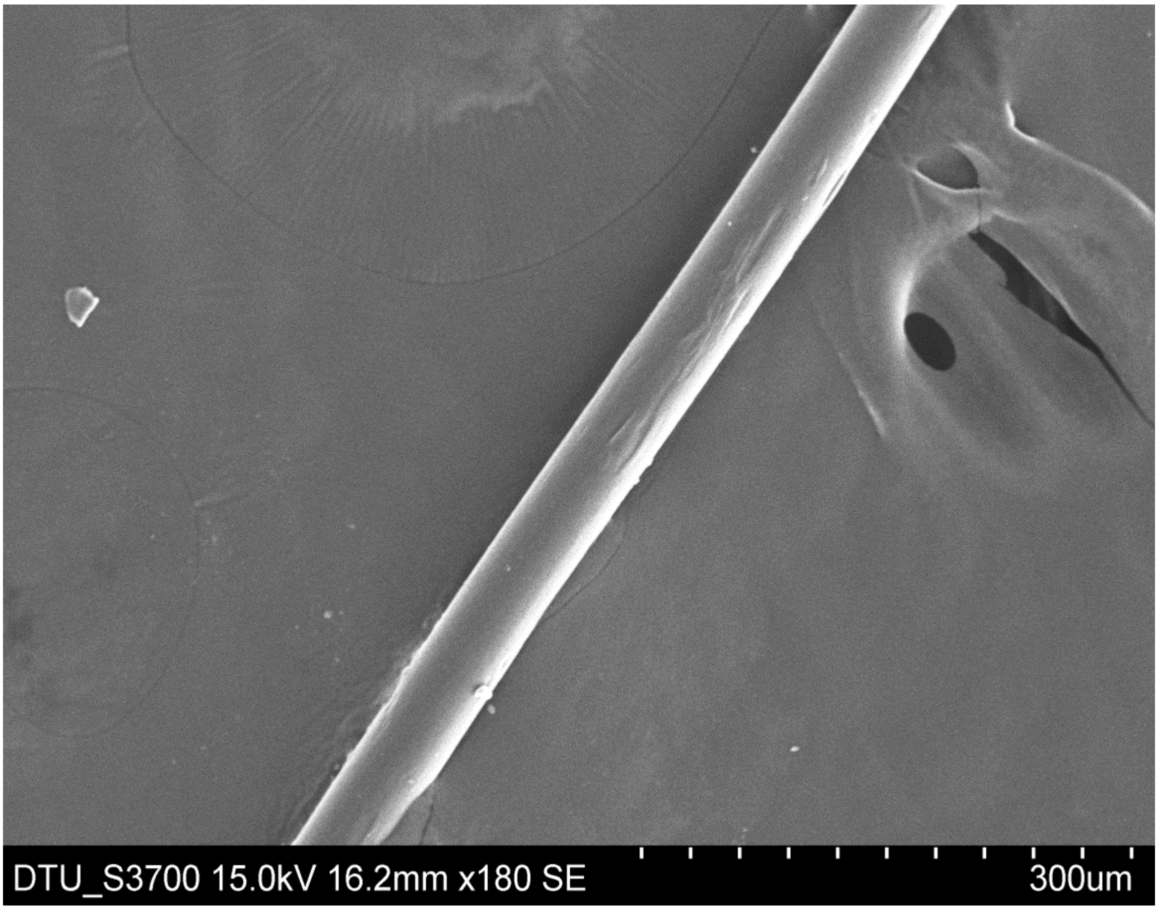

Fig.20: Polypropylene Fibre at 300um Scale

4.1.9 Proctor compaction test: IS: 10074(1982):

Sample weight=2.5Kg

Mass of mould +base plate (W) =4286gm

Volume of mould (V) =1000cc

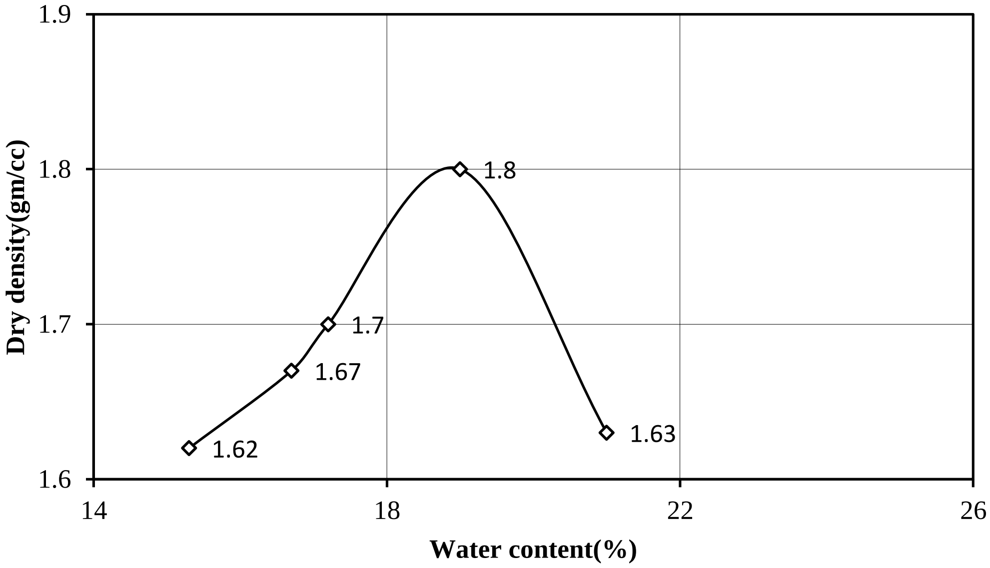

Fig.21: Variation of Dry density with water content of soil

According to fig.21, I found that the Maximum dry density of soil 1.8gm/cc at optimum moisture content of 19%.The application of proctor compaction test in soil engineering used to determine the optimal moisture content at which a given soil type will become most dense and achieve its maximum dry density. Too much water will make the soil squishy and temporarily reduce bearing capacity and too dry soil won't make the bond thoroughly. So we have to take the optimum value at which the soil becomes compact at MDD.

The application of Optimum moisture content and maximum dry density is used to study the various Experiments like UCS, Indirect tensile test, CBR, Direct shear test.

4.1.10Unconfined compressive test, IS: 2720(Part 10)(1987):

Optimum water content=19%　　Mass of soil=500gm

Dry density=1.8gm/cc　　Length of specimen=115mm

Dia. of specimen =50mm

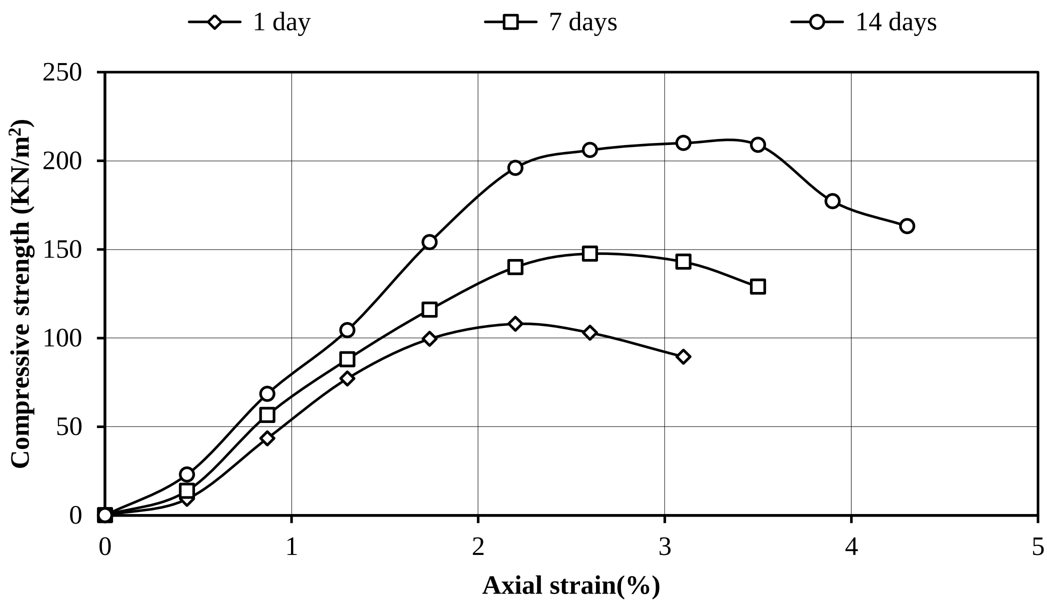

Fig.22: Variation of Compressive strength with Axial strain of soil at different days of curing

According to fig.22, it is observed that the unconfined compressive strength of the soil is different for different curing period. If I am taking one day, Seven days and fourteen days curing period then it was found that unconfined compressive strength of the soil is108KN/m^2, 147.6KN/m^2 and 210KN/m^2, also the undrained shear strength of the soil is 54KN/m^2,73.8KN/m^2 and105KN/m^2

From above result it is discussed that as the curing period of the sample increases, the unconfined compressive strength and undrained shear strength of the soil increases. The significance of this test is to quickly find out the shear strength of the cohesive soil. The practical application of UCS test is used to obtain the rough estimates of soil strength for the design and stability analysis of foundation, retaining wall, slope sand embankments.

4.1.11 California bearing ratio test (Unsoaked condition), IS: 2720(Part 1) (1987):

Optimum water content=19% Mass of mould=7950gm

Mass of soil=500gm Dry density=1.8gm/cc

From the Load-Penetration curve fig.23, it is observed that the CBR value of soil at 2.5mm of penetration is 1.25% and for 5mm of penetration it will be 1.1%. So the higher value of CBR is adopted. Generally the CBR value of 2.5mm of penetration is higher than 5mm of penetration.

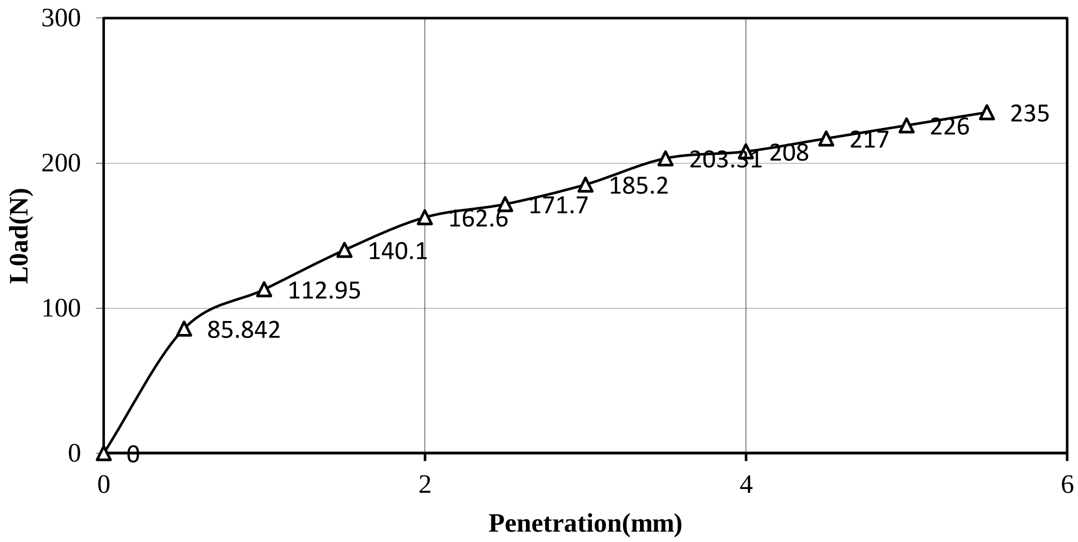

Fig.23: Variation of Load with Penetration of Soil

The application of CBR test in Geotechnical engineering is used to determine the relative bearing ratio and expansion characteristics of soil, which is used for design of roads, pavement and runways.

Fig.24: Testing of sample

Fig.25: Penetration depth in sample

4.1.12 Indirect tensile strength test (Brazilian test), IS: 10082(1982):

The Indirect tensile strength of the soil is determined by IS specification and it was found that the tensile strength of the soil is different for different curing Period. The tensile strength of seven days and fourteen days curing period is 0KN/m^2 and 64KN/m^2

The Practical application of Brazilian test in soil engineering is used for the analysis and design of impermeable cores of earthen dams against cracking. So it is required to knowledge about the tensile forces act on the earthen dam and what is the tensile strength of soil. For any stress and deformation analysis of an earth structure when a small portion of it is expected to be in tension, Brazilian test is very useful. In order to investigate behavior of soils in tension the Brazilian tensile test has been employed and found advantageous over other methods.

4.1.13 Direct shear test IS: 2720(Part 11) (1983):

Size of box=6cmx6cmx3cm Area of box=36cm2
Mass of box + base plate + porous stones +grid plate=3250gm
Mass of box +base plate + porous stones +grid plate +soil specimen=3500gm
Normal stress=50KN/m2, 100KN/m2, 150KN/m2

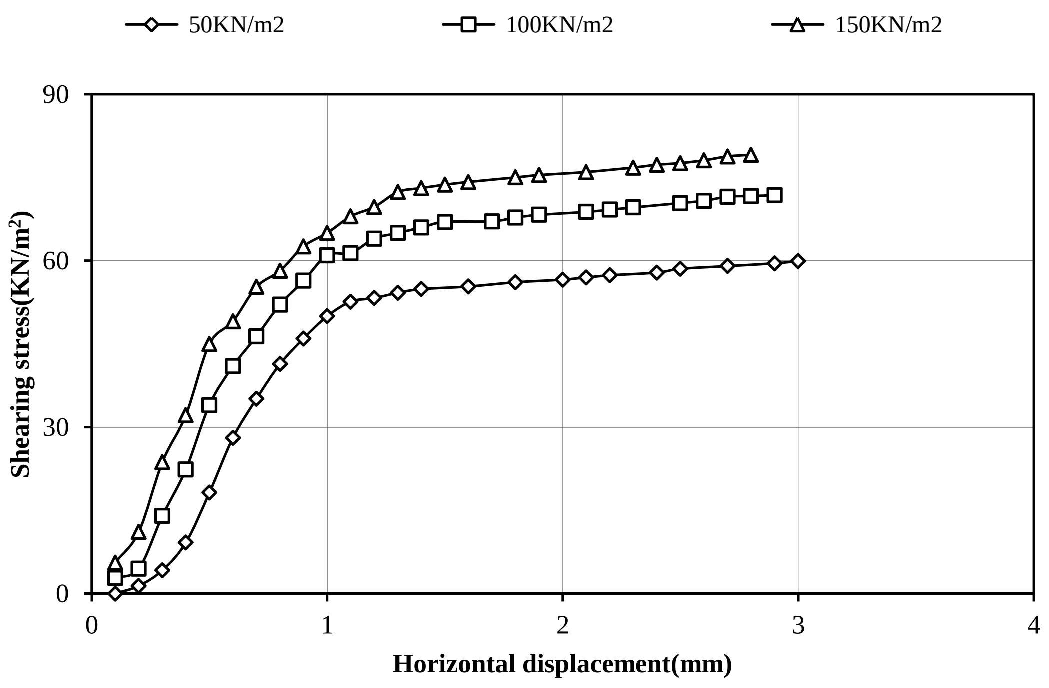

Fig.26: Variation of Shearing Stress with Horizontal Displacement of Soil at different normal stress

From the fig.26, it is observed that as the normal stress increases, the shearing stress of the soil also increased. I did this test at three different normal stresses that is 50KN/m^2, 100KN/m^2 and 150KN/m^2 and I found that shearing stress corresponding to normal stress is 60.4KN/m^2, 71.8KN/m^2,79.23KN/m^2. These both stresses used to calculate the cohesion and angle of internal friction.

Table.9: Shearing stress vs. Normal stress

S.No.	Normal stress(KN/m^2)	Shearing stress(KN/m^2)
1	50	60.4
2	100	71.8
3	150	79.23

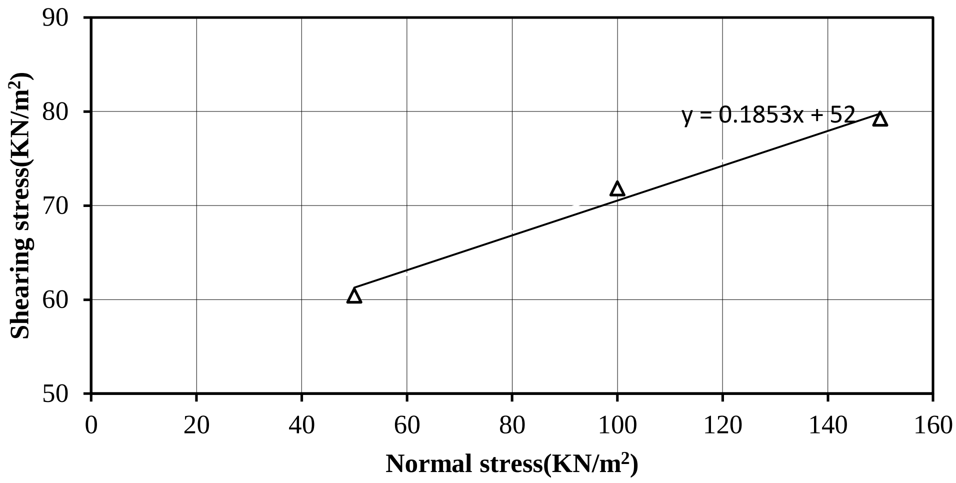

Fig.27: Variation of Shearing Stress with Normal Stress of Soil

From the fig.27 it is found that, y=0.1853x+52 is the equation of line. Where 0.1853 is the slope and 52 is the intercept of line. The intercept shows the cohesion of the soil that is C=52KN/m^2 and the angle of internal friction is 9.54 degree. According to this I found that the shear strength of the soil is very less and it is not acceptable.

The practical application of the direct shear test is used to study the shear strength of soil on which structure like embankment, dams, and canal is constructing. Shear strength is an important parameter. If the shear strength of the soil is less, then the structure will fail due to slippage condition. So for designing the embankment, retaining wall it is very much necessity to do the direct shear test.

4.2 SOIL REINFORCED WITH JUTE FIBRE

4.2.1 Proctor compaction test: IS: 10074(1982):

Sample weight=2.5Kg

Mass of mould +base plate (W) =4286gm

Volume of mould (V) =1000cc

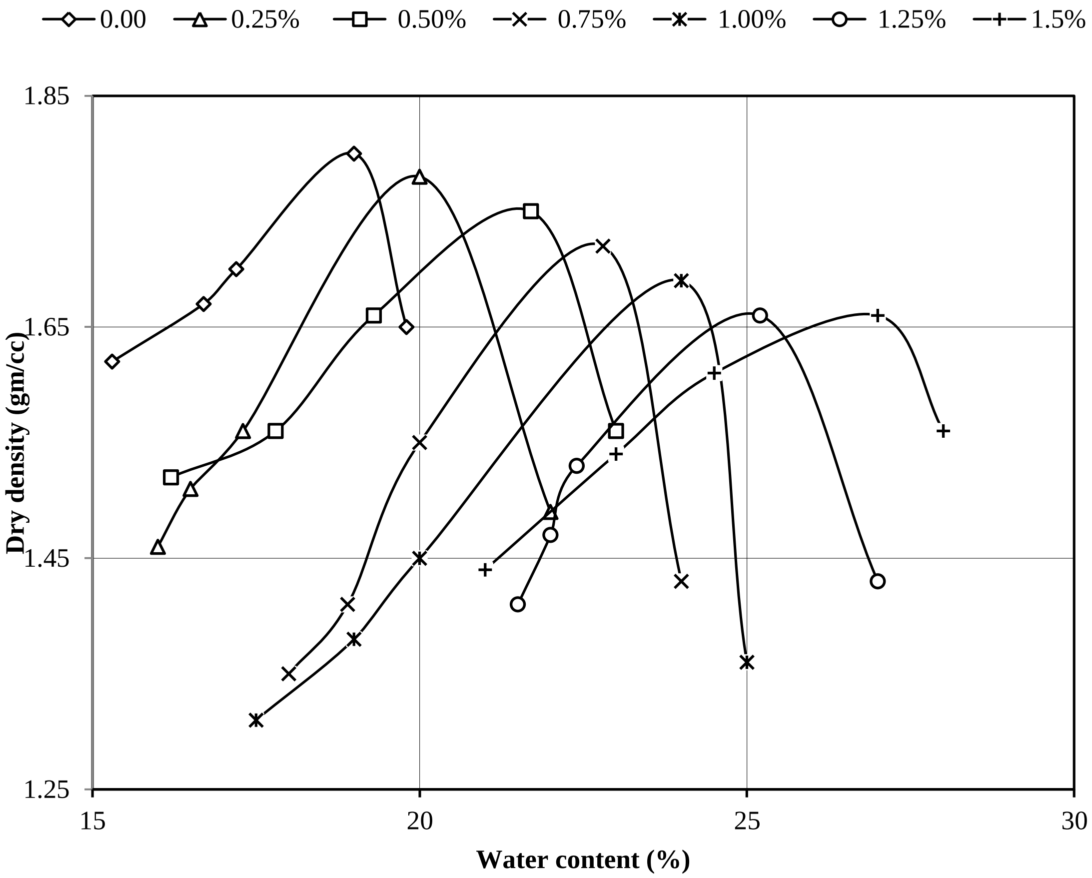

Fig.28: Variation of Dry density with water content of soil reinforced with different percentage of Jute Fibre

From fig.28, I found that as the fibre content increases from 0.25% to 1.5%, it reduces the maximum dry density and increases the optimum moisture content of soil. The decrease in maximum dry density of treated soil is the reflection of the resistance offered by the flocculated soil structure and the increase in optimum moisture content means is additional water held within the flocculated soil structure resulting from Jute fibre interaction.

It is clearly seen from the fig.28 that the compaction curve for soil is very sharp near the OMC, but the compaction curve for soil mixed with Jute fibre became flat near the OMC. This condition is very beneficial in field construction of the sub grade of roads in such soil. The other reason to decrease the dry density is that Jute fibre has low specific gravity and this low density fibre replaces the higher density soil particle

Table.10: Variation of MDD and OMC with different Percentage of Jute Fibre Content

S.No	% of Jute fibre	Maximum dry density(gm/cc)	Optimum moisture content (%)
1	0	1.8	19
2	0.25	1.78	20
3	0.50	1.75	21.7
4	0.75	1.72	22.8
5	1.0	1.69	24
6	1.25	1.66	25.2
7	1.5	1.66	27

Table.10, presents the result of OMC and MDD when expansive soil reinforced with Jute fibre. Comparing the result with Unreinforced soil it is observed that OMC increases by 19%, 20%, 21.7%, 22.8%, 24%, 25.2% and 27% and MDD decreases by 1.8gm/cc, 1.78gm/cc, 1.75gm/cc, 1.72gm/cc, 1.69gm/cc, 1.66gm/cc and 1.66gm/cc at fibre content of 0.25%, 0.50%, 0.75%, 1.0%, 1.25% and 1.5%.

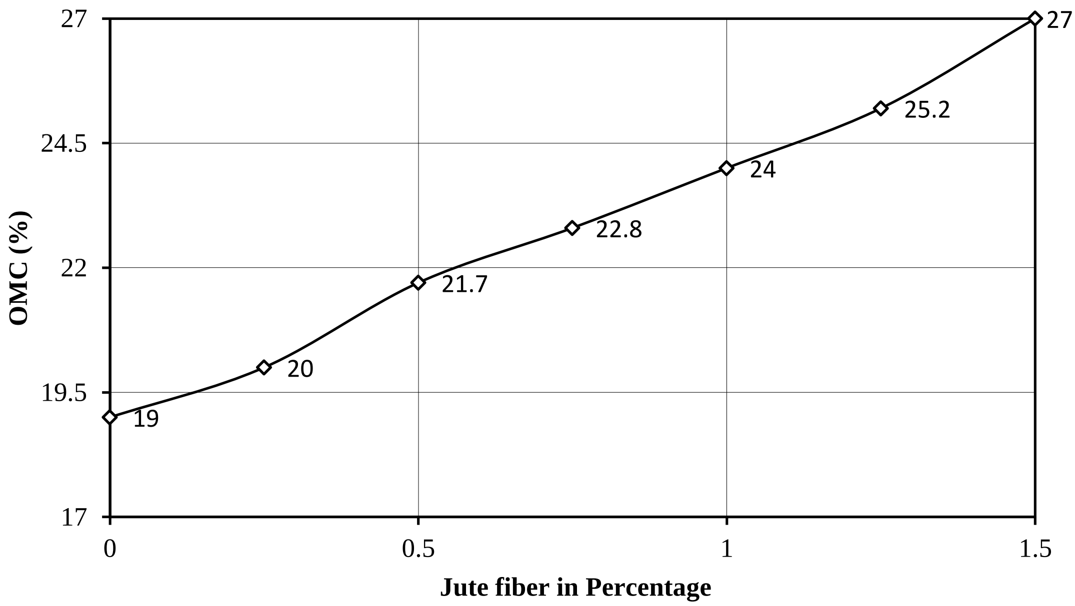

Fig.29: Variation of OMC with Jute Fibre in different Percentage

From fig.29, it is clearly seen that from as the fibre content increases from 0% to 1.5% the OMC curve increases linearly.

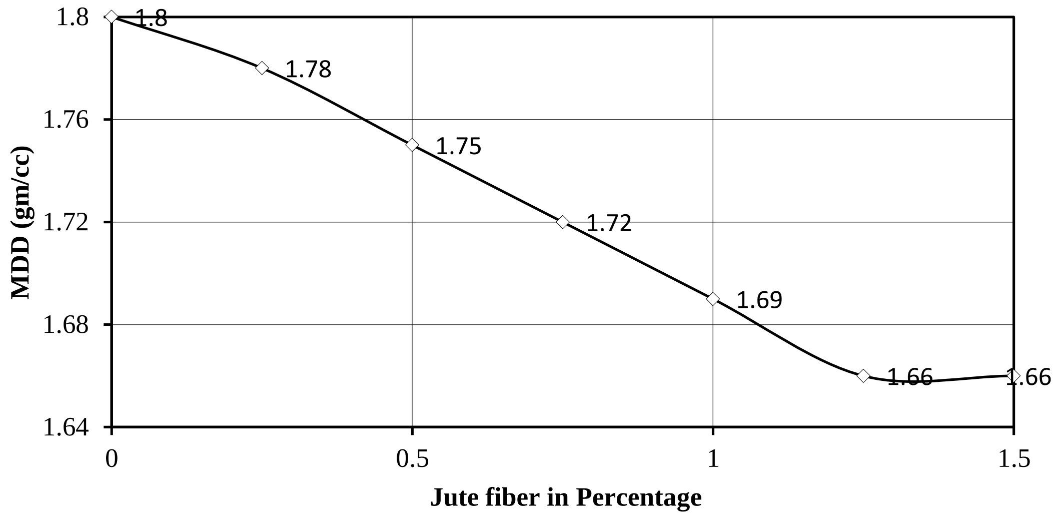

Fig.30: Variation of MDD with Jute Fibre in Different Percentage

From fig.30, it is clearly observed that as the fibre content increases from 0% to 1.25% maximum dry density of the soil decreases linearly and from 1.25% to 1.50% it will const.

4.2.2Unconfined compressive test IS: 2720(Part 10) (1987):

Optimum water content at different Percentage of fibre content
Mass of soil+ fibre=500gm
Dry density at different percentage of fibre content
Length of specimen=115mm
Dia. of specimen =50mm

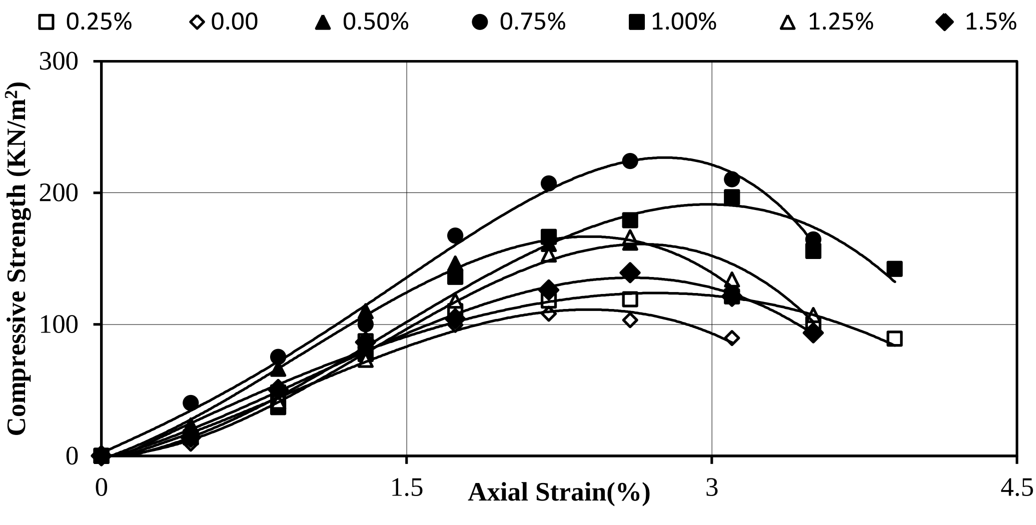

Fig.31: Variation of Compressive Strength with Axial Strain of soil reinforced with jute Fibre in different Percentage at 1 Day Curing Period

From fig .31, it found that as the fibre content increases from 0.25% to 1.5%, the one day compressive strength of the expansive soil is increases up to the fibre content of 0.75% and further from 0.75% to 1.5% it will decreases. It means that the optimum value of fibre content to find the unconfined compressive strength for expansive soil is 0.75%.

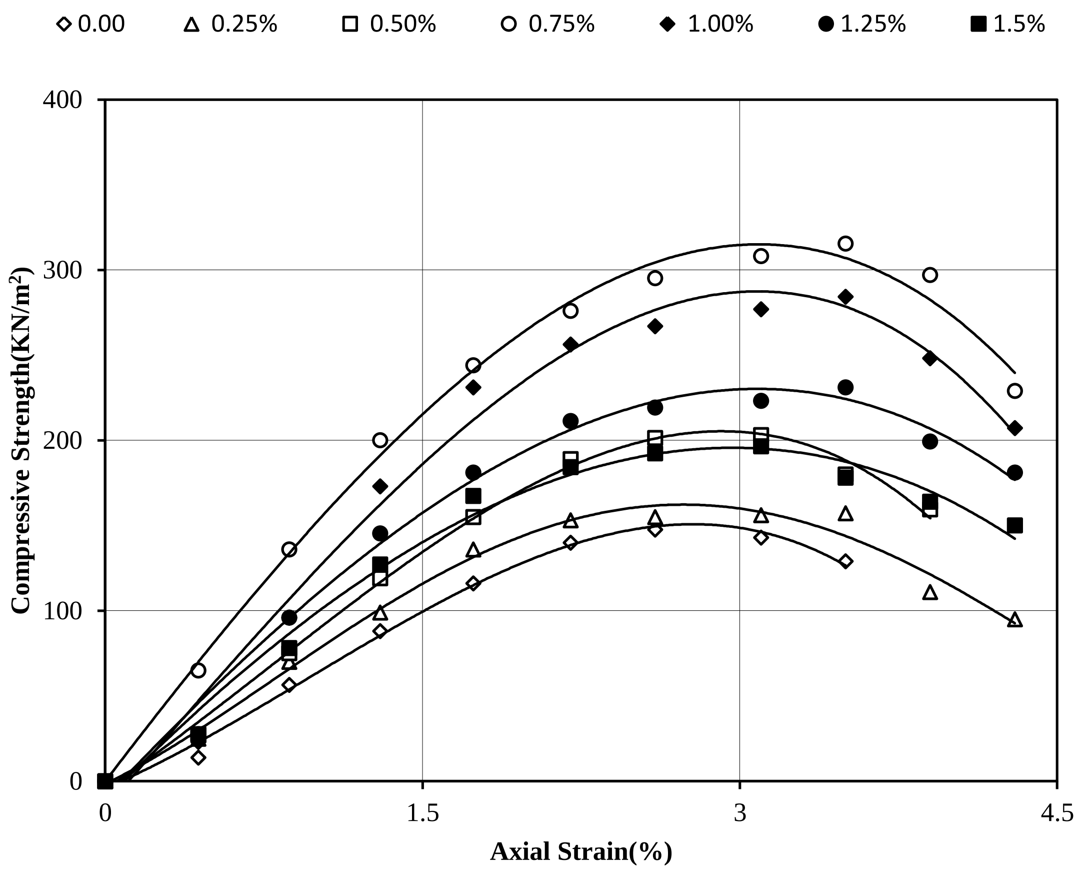

Fig.32: Variation of Compressive Strength with Axial Strain of soil reinforced with Jute Fibre in different Percentage at 7 Days Curing Period

From fig .32, it was found that as the fibre content increases from 0.25% to 1.5%, the Seven days compressive strength of the expansive soil is increases up to the fibre content of 0.75% and further from 0.75% to 1.5% it will decreases. It means that the optimum value of fibre content to find the unconfined compressive strength for expansive soil is 0.75%.

From the above discussion it is observed that 7 days compressive strength is more than that of one day at each stage of fibre content.

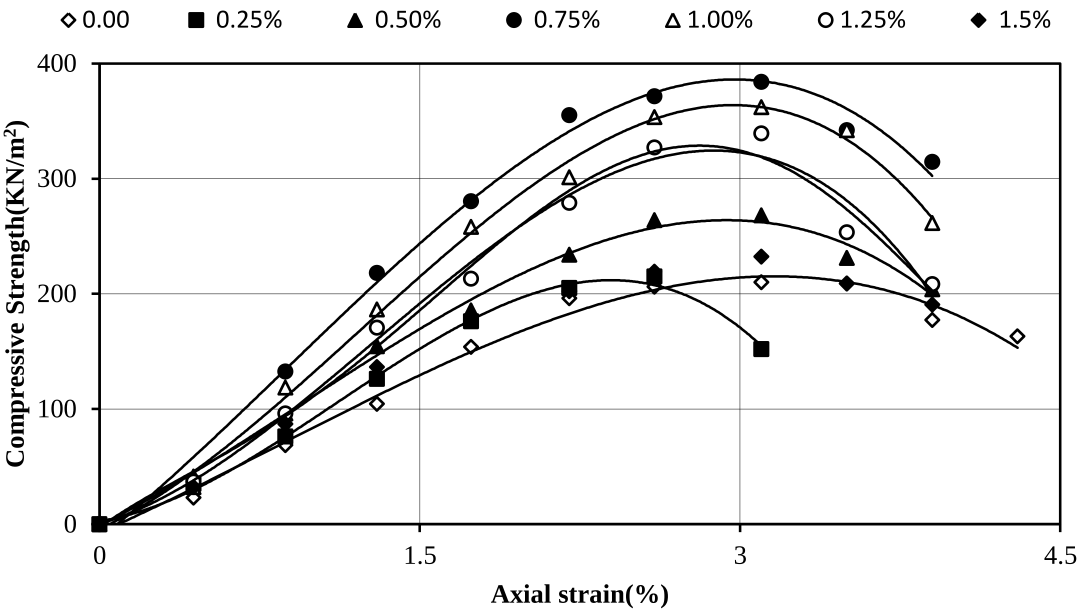

Fig.33: Variation of Compressive Strength with Axial Strain of soil reinforced with Jute Fibre in different Percentage at 14 Days Curing Period

From fig.33, it was found that as the fibre content increases from 0.25% to 1.5%, the 14 days compressive strength of the expansive soil also increases up to the fibre content of 0.75% and further from 1%, to 1.5% it will decreases. It means that the optimum value of fibre content to find the unconfined compressive strength for expansive soil is 0.75%.

But the 14 days compressive strength of expansive soil reinforced with Jute fibre is more than that of 1and 7 days.

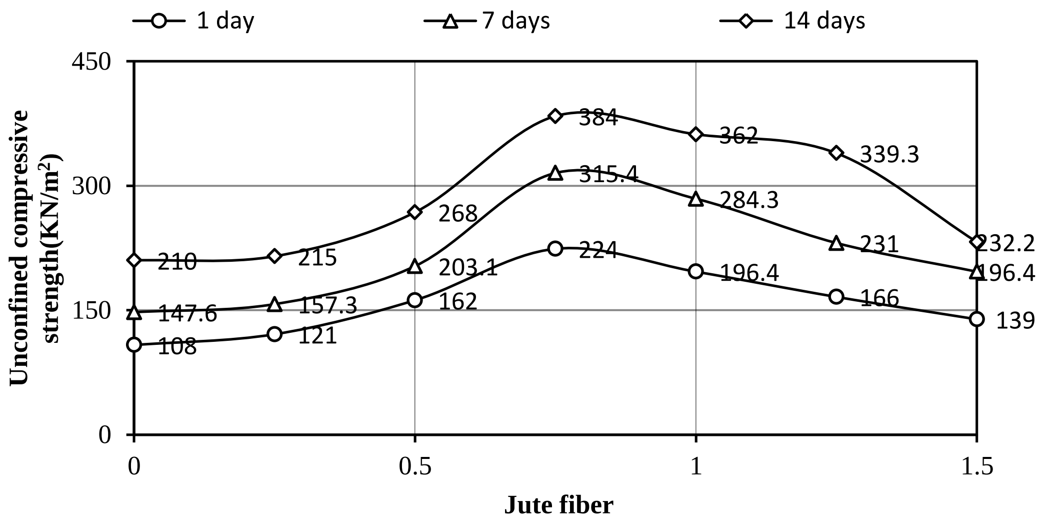

Fig.34: Variation of UCS with different Percentage of Jute Fibre

According to fig.34, it gives the overall result of unconfined compressive strength of expansive soil reinforced with Jute fibre at a fibre content of 0.25% to 1.5%. According to the fig it was discussed that as the fibre content increases the unconfined compressive strength of soil increases up to 0.75% of fibre content for one day , 7 days and 14 days curing and then it will decreased. The variation of unconfined compressive strength with fibre at curing period is given below in table11.

Table.11: Unconfined Compressive Strength at different % of Jute Fibre at different Curing Period

Sample	**Curing days**	**Percent of fibre**	**Unconfined compressive strength(KN/m^2)**
Expansive soil	1days	0	108
		0.25	121
		0.50	162
		0.75	224
		1.00	196.4
		1.25	166
		1.50	139
	7 days	0	147.6
		0.25	157.3
		0.50	203.1
		0.75	315.4
		1.00	284.3
		1.25	231
		1.50	196.4
		0	210
		0.25	215
		0.50	268
		0.75	384

	14 days	1.00	362
		1.25	339.3
		1.50	232.2

The various results observed by studying the table.11:

One day Unconfined compressive strength of expansive soil at 0%, 0.25%, 0.50% ,0.75% ,1.0% ,1.25% and 1.50% of Jute fibre is 108KN/m^2, 121KN/m^2, 162KN/m^2, 224KN/m^2, 196.4KN/m^2, 166KN/m^2 and 139KN/m^2 and the percentage of variation of UCS with respect to soil is 12% ,50% ,107% ,81% ,53% and 28%.The maximum value of Unconfined compressive strength is 224KN/m^2 at fibre content of 0.75%

Seven days Unconfined compressive strength of expansive soil at 0%, 0.25%, 0.50%,0.75%,1.0%,1.25% and 1.50% of Jute fibre is 147.6KN/m^2, 157.3KN/m^2, 203.1KN/m^2, 315.4KN/m^2, 284.3KN/m^2, 231KN/m^2 and 196.4KN/m^2 and the percentage of variation of UCS with respect to soil is 7% ,38% ,113% ,92% ,56% and 33%.The maximum value of Unconfined compressive strength is 315.4KN/m^2 at fibre content of 0.75% .

Fourteen days unconfined compressive strength of expansive soil at 0%, 0.25%, 0.50%, 0.75%, 1.0%, 1.25% and 1.50% of Jute fibre is 210KN/m, 215KN/m^2, 268KN/m^2, 384KN/m^2, 362KN/m^2, 339.3KN/m^2 and 232.2KN/m^2 and the percentage of variation of UCS with respect to soil is 2%, 27%, 82%, 72%, 61% and 10%. The maximum value of unconfined compressive strength is 384KN/m^2 at fibre content of 0.75%.

From the above discussion it was found that with increases the percentage of fibre and curing period the unconfined compressive strength of the soil increases.

4.2.3California bearing ratio test (Unsoaked condition), IS: 2720(Part 1) (1987):

Optimum water content at different % of fibre   Mass of mould=7950gm
Mass of soil=500gm   Dry density at different % of fibre content

According to fig.35, it is finding that as the % of fibre content increases from 0.25% to 1.5%, the load carrying capacity of the expansive soil increases up to 1% of fibre

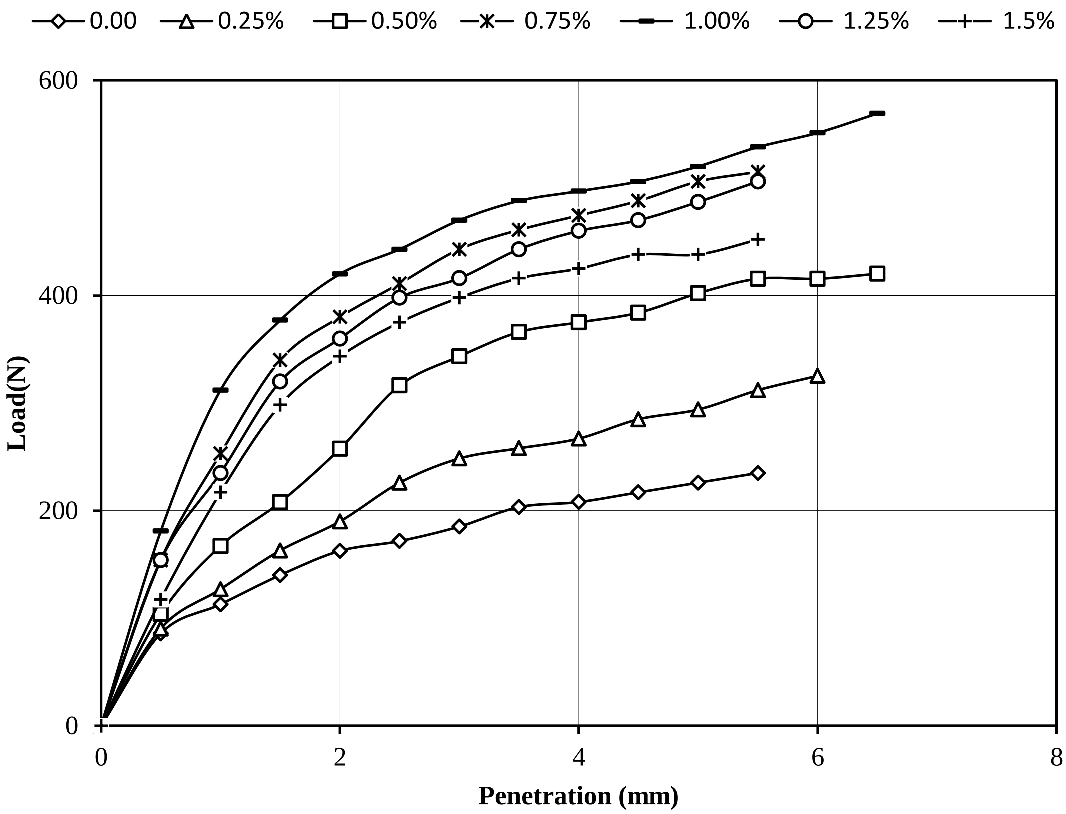

Fig.35: Variation of Load with Penetration of soil reinforced with different Percentage of Jute Fibre

Content and further it will decrease. It means that for California bearing ratio test the optimum percentage of the fibre to calculate the test load is at 1%.

From the above discussion it was found that with increases in the load carrying capacity of expansive soil resulted in increases in the CBR value of soil It means this soil is safely used in sub grade, embankment.

The reason behind the increase of CBR value is the inclusion of Jute fibre into the soil mass. Jute fibre improves its load-deformation behaviour by interacting with soil particle through surface friction and also by interlocking. The function of bond is to transfer the stress from soil to fibre and Increases the penetration resistance thus increases the CBR value.

The strength and stiffness is another factor is to increases the CBR value of the soil. As the fibre content increases the strength and stiffness of the soil also increases which increases the CBR value of the soil.

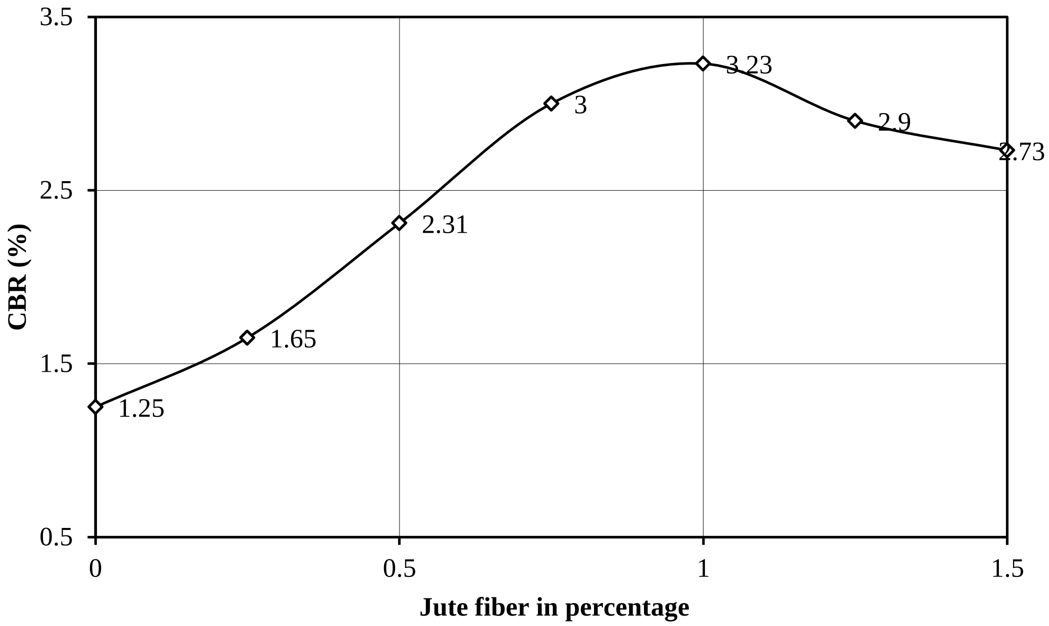

Fig.36: Variation of CBR with Jute Fibre in Different Percentage

From the fig.36, it is found that the CBR value of the expansive soil is Increases up to 1% of Jute fibre and further it will decrease. It means that the optimum value of CBR at 1% of fibre content. The variation of CBR with Jute fibre can be seen in table 12

Table.12: CBR Value at different % of Jute Fibre

S.No.	% of fibre	CBR (%) (Unsoaked condition)
1	0	1.25
2	0.25	1.65
3	0.50	2.31
4	0.75	3
5	1.00	3.23
6	1.25	2.9
7	1.5	2.73

Table.12, presents the result of CBR Test when expansive soil reinforced with Jute fibre. When I compared the result with unreinforced soil, it is finding that inclusion of fibre causes significant improvement of CBR value. The CBR values are observed to be improved by 1.25%, 1.84%, 2.67%, 3.49%, 4.1%, 4.78% and 4.15% at fibre content of 0.25%, 0.50%, 0.75%, 1.0%, 1.25% and 1.5%.

CBR value used in sub grad, so it is necessary to find out the percentage of variation.

The percentage of increase in the CBR value are observed by 32%, 84%, 140%, 158%, 132% and 118% with respect to the untreated soil.

4.2.4 Free swell index, IS: 2720 (part XL) (1977):

Free swell index is determined by IS specification. According to the experimental investigation it is found that as the fibre content increases from 0.25% to 1.5% the free swell index of the soil decreases.

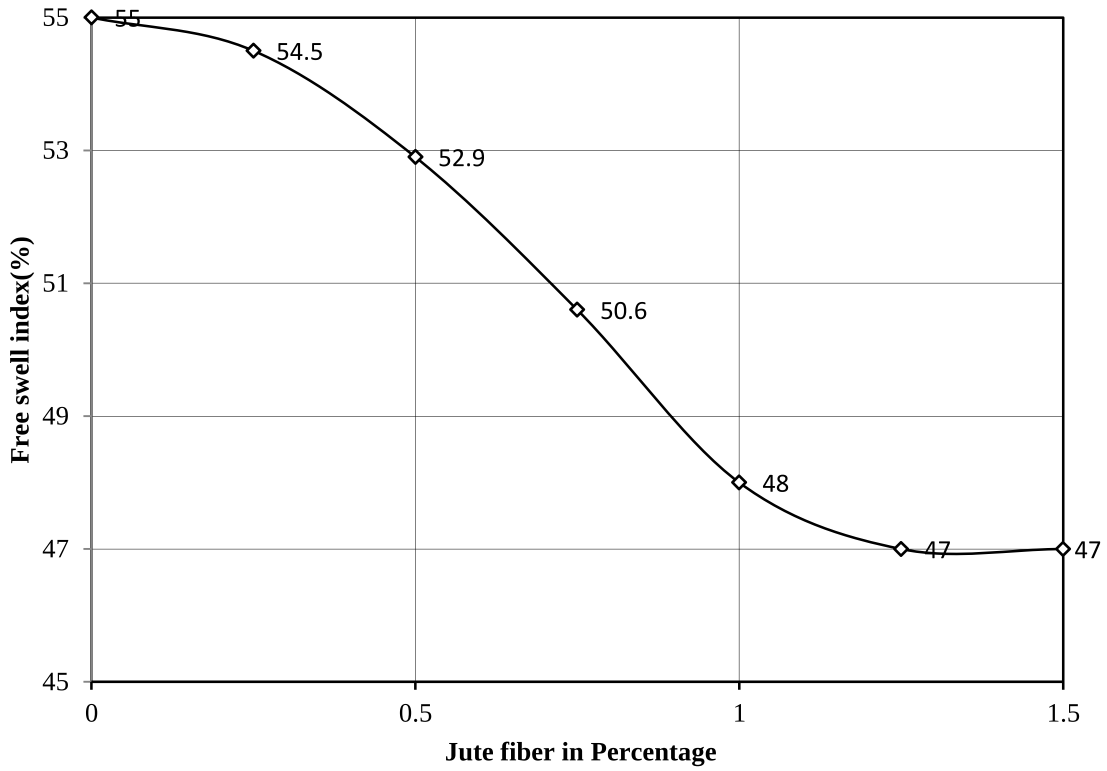

Fig.37: Variation of Free Swell index with Jute Fibre in different Percentage

From fig.37, it was found that as the fibre content increases from 0% to 1.25% the free swell index of the soil decreases and further it will take constant value from 0.25% to 1%.

The reason for reducing the free swell index is that when the water in contact with soil-fibre mixture, fibre absorbs moisture and there is very less amount of water in contact with soil so due to this the swelling action of the soil decreases.

Basically this test is conducted before designing of dams, embankment, and canals like structure which is built up on expansive soil because there is excess amount of seepage of water due to this there is chance of failure of structure. The decrease of free swell index shown in table below:

Table.13: Free Swell Index at different Value of Jute Fibre

S.No.	% of fibre	Free swell index (%)
1	0	55
2	0.25	54.5
3	0.50	52.9
4	0.75	50.6
5	1.0	48
6	1.25	47
7	1.5	47

Table.13, presents the result of free swell index when the soil is reinforced with fibre. When I compared the result with unreinforced soil then it was found that there is an improvement of soil with increases of percentage of fibre. Free swell index values of the soil are observed to be decreased by 55%, 54.5%, 52.9%, 50.6%, 48%, 47% and 47% with at fibre content of 0%, 0.25%, 0.50%, 0.75%, 1.0%, 1.25% and 1.5% .

4.2.5 Indirect tensile strength test (Brazilian test), IS: 10082(1982):

Optimum water content at different Percentage of fibre content
Mass of soil+ fibre=500gm
Dry density at different percentage of fibre content
Length of specimen=100mm
Diameter of specimen =50mm

The study of the tensile strength of the soil is very important factor because many structures were damaged due to the tensile forces. So the following result find out by doing this test to study the behaviour of the soil in tension, so according to investigation it will be find out that the tensile strength of the soil is very less and there is an need of improvement.

From fig.38, it is observed that as the fibre content increases from 0.25% to 1.5%, the tensile stress of the expansive soil is increased. The increase in tensile strength of soil up to the fibre content of 0.75% for 7 days curing period and thereafter from 0.75% to

1% it will decrease and further it will takes const position in between 1% to 1.5% and for 14 days of curing period it will increases up to 1% of fibre content and thereafter it will decreased. But the tensile stress of 14 days curing period is more than that of 7 days curing period.

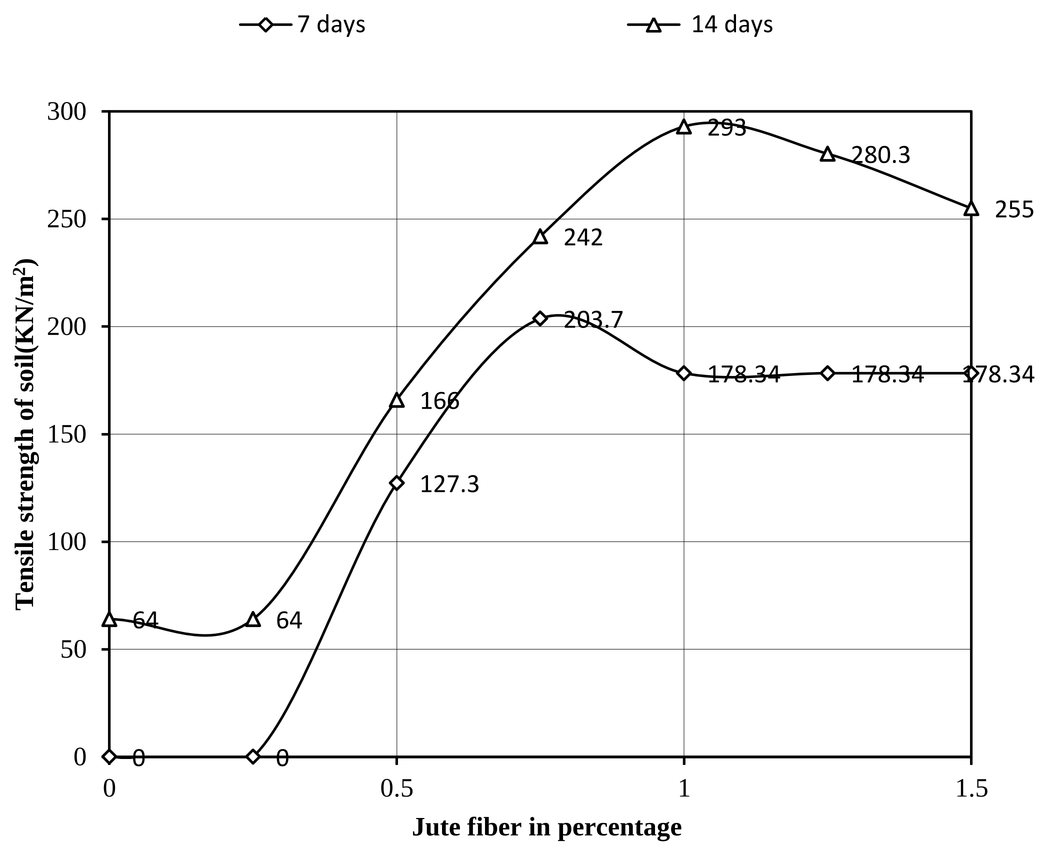

Fig.38: Variation of tensile strength with Jute Fibre reinforced in soil at different days of curing

Jute fibre is natural fibre and it is produced by natural process. The tensile strength of the Jute fibre is high, so due to the high tenacity property of Jute fibre it overcome the tensile stress which is developed in soil .That is why I used the Jute fibre in soil. The tensile strength of the soil depends upon the length and diameter of the fibre. If the diameter of the fibre is more the contact area of fibre with soil is also more and it will give more strength to the soil. Many structure fails due to tensile stress so the study of this test is very important because fibre give more tensile strength as compared to other stabilizing agent. The tensile strength of the soil at 7 days and 14 days curing period are given below in table14:

Table.14: Tensile Strength of Soil Reinforced with Jute Fibre at different Curing Period

Sample	**Curing days**	**Fibre (%)**	**Tensile strength(KN/m^2)**
Expansive soil	7 days	0	0
		0.25	0
		0.50	127.3
		0.75	203.7
		1.0	178.34
		1.25	178.34
		1.5	178.34
	14 days	0	64
		0.25	64
		0.50	166
		0.75	242
		1.00	293
		1.25	280.3
		1.50	255

Table.14, presents the tensile strength of the soil when it is reinforced with Jute fibre. When I compare the result with untreated soil then I found that the tensile strength of the soil is improved.

The 7 days tensile strength of the soil is increased by 0KN/m^2, 0KN/m^2, 127.3KN/m^2, 203.7KN/m^2, 78.34KN/m^2, 178.34KN/m^2, and 178.34KN/m^2 when it is reinforced with 0%, 0, 25%, 0.50%, 0.75%, 1.00%, 1.25% and 1.5% Jute fibre.

The 14 days tensile strength of the soil is increased by 64KN/m^2, 64KN/m^2, 166KN/m^2, 242KN/m^2, 293KN/m^2, 280.3KN/m^2 and 255KN/m^2 when it is reinforced with 0%, 0, 25%, 0.50%, 0.75%, 1.00%, 1.25% and 1.5% Jute fibre.

4.2.6 Direct shear test, IS: 2720(Part 11) (1983):

Size of box=6cmx6cmx3cm Area of box=36cm^2

Mass of box + base plate + porous stones +grid plate=3250gm

Mass of box +base plate + porous stones +grid plate +soil specimen+ fibre=3500gm

Normal stress=50KN/m^2, 100KN/m^2, 150KN/m^2

According to the fig .39, it is clearly observed that as the fibre content increases from 0.25% to 1.5%, the shearing stress of the soil increases as compared to untreated soil when the Normal load applied is 50KN/m^2.

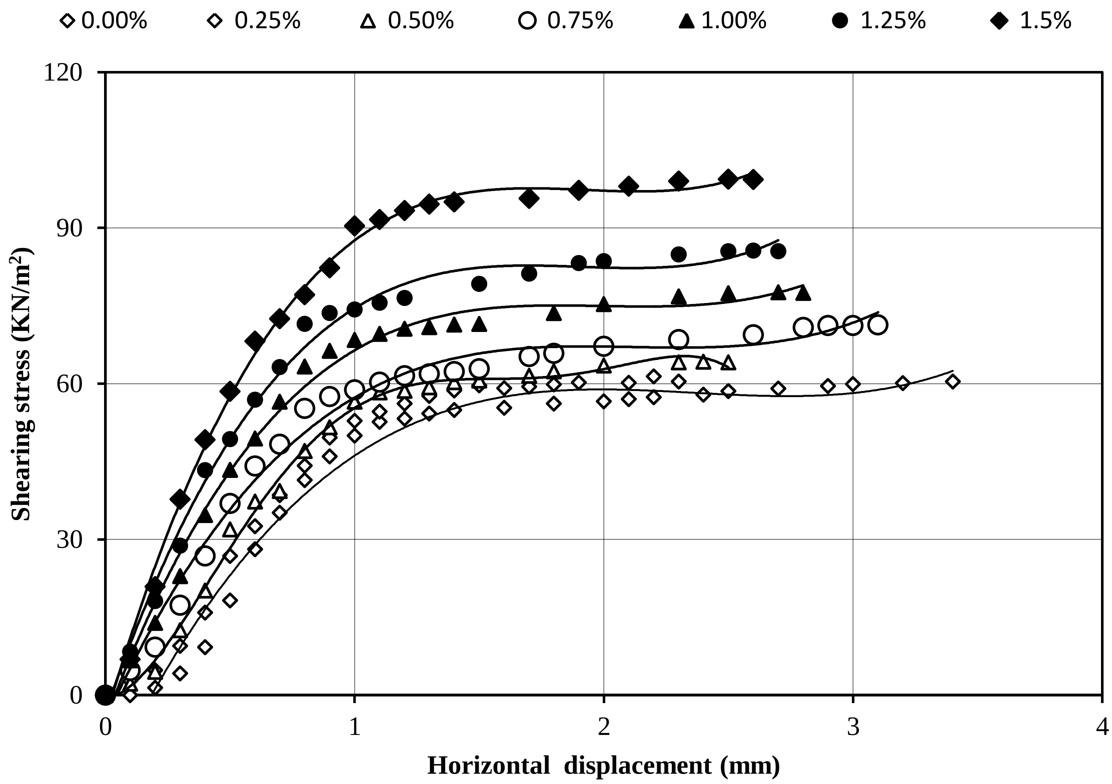

Fig.39: Variation of Shearing stress with horizontal displacement of Soil reinforced with Jute Fibre at Normal Stress 50KN/m^2

For the fibre content of 0.25% to 0.75%the shearing stress of the soil increases very less for all value of shear displacement and all curves up to this % is very close to each other but as we move further from 0.75% to 1.25% the shearing stress increases suddenly and for 1.5% of fibre content it will give the maximum value of shearing .

According to the fig.40, it was observed that as the fibre content increases, the shearing strength of the soil also increases when the normal load applied is 100KN/m^2. I studied the fig and found that for 0.25% to 0.75% fibre content the shearing stress curve is very close to each other , it means in this % shearing stress value increases very less but as we move further , the shearing stress curve is far apart at 1% fibre content, it means in this fibre content shearing stress increases suddenly but for 1.25% the stress curve move very close to 1% of fibre content and for 1.5% it will again far apart , it means there is no much variation of shearing stress at 1.25% as compared to 1% and For 1.5% it will give maximum value of shearing strength.

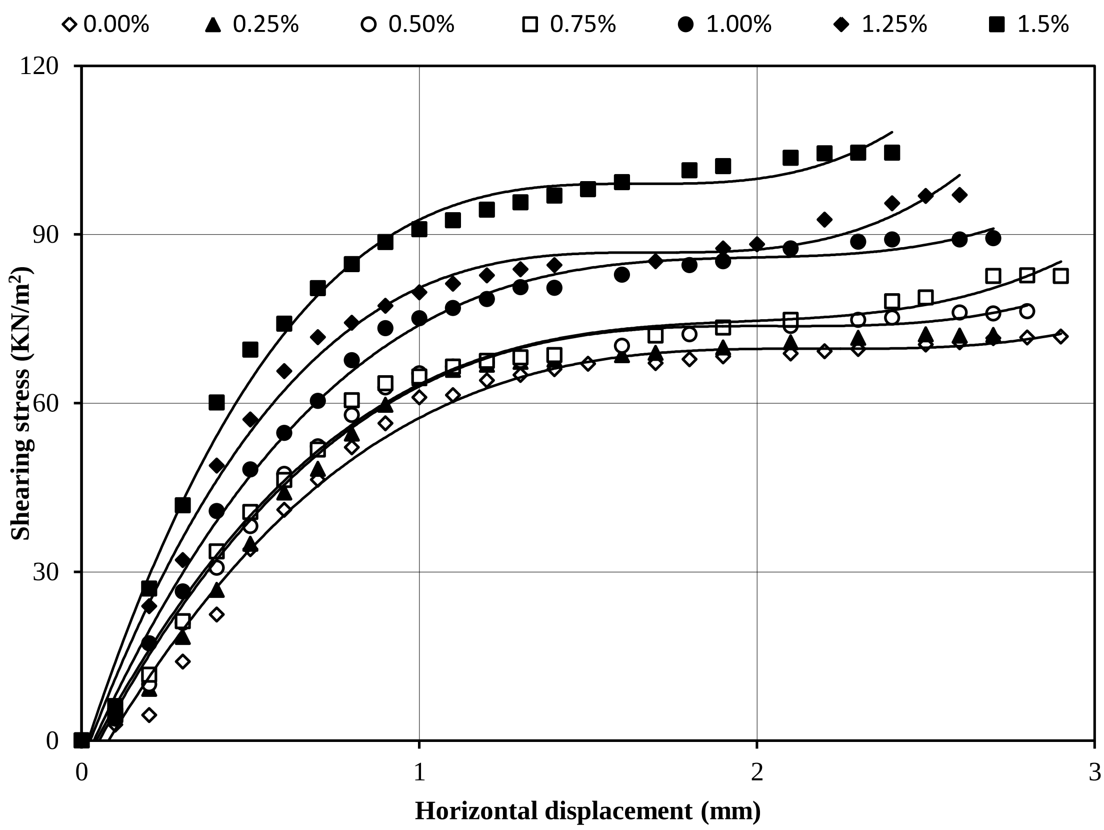

Fig 40: Variation of Shearing stress with horizontal displacement of Soil reinforced with Jute Fibre at Normal Stress $100KN/m^2$

From the figure 40 it is clearly noticed that the shearing stress value at $100KN/m^2$ is more than that of $50KN/m^2$ at each stage of fibre content for all values of horizontal shear displacement

According to the fig.41, it is observed that as the fibre content increase the Shearing stress value of soil for all value of horizontal displacement also increases. From fig.41 shows that for 0.25%, 0.50% and 0.75% fibre content shearing stress curve is very close to each other it means shearing stress value increases very less for this %. But if I studied further from 0.75% to 1% the shearing stress curve is far apart from previous one but for this fibre content it will just overlap with each other, it means in this % of fibre the variation is almost negligible. For 1.5% the shearing stress curve is very much far apart and gives maximum value.

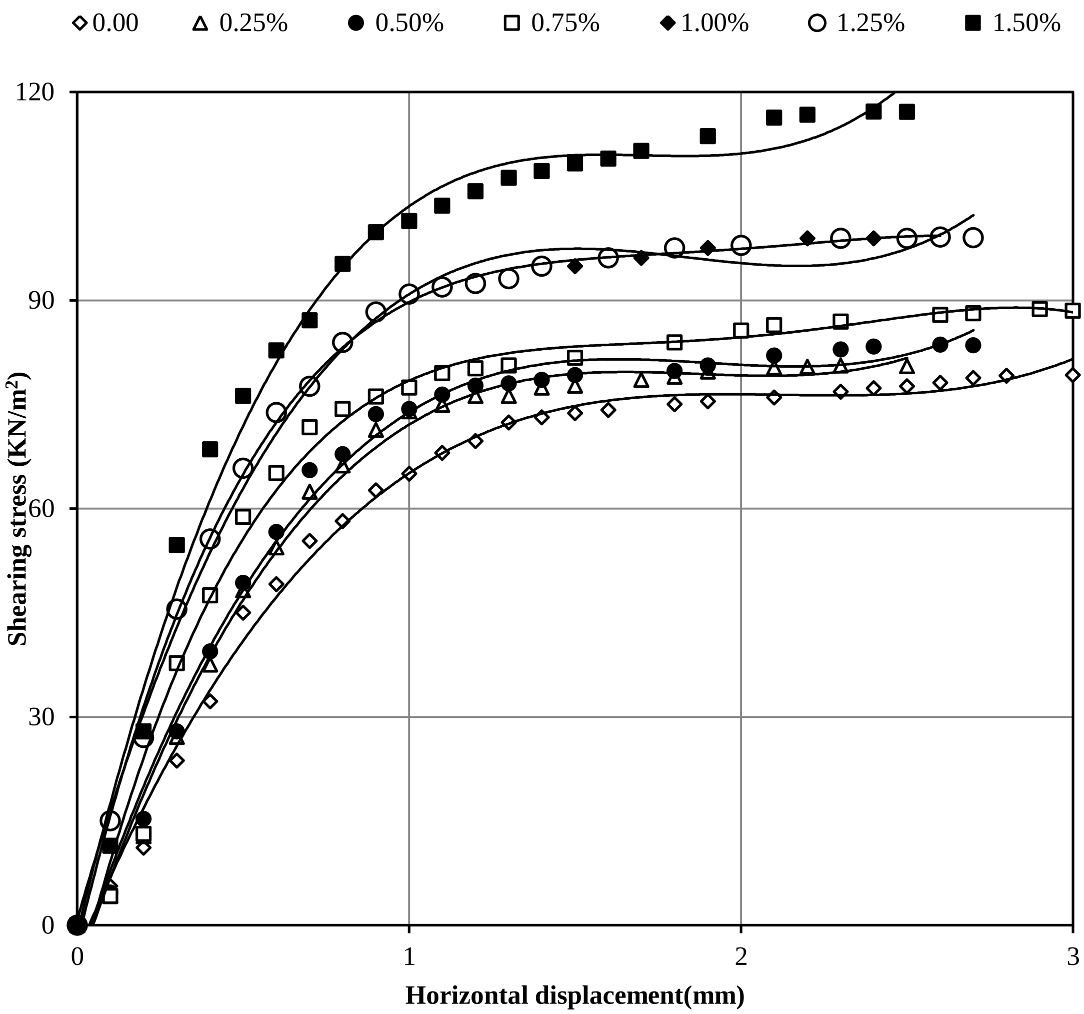

Fig.41: Variation of Shearing stress with horizontal displacement of Soil reinforced with Jute Fibre at Normal Stress 150KN/m^2

The shearing stress value correspondence to all horizontal shear displacement at 150KN/m^2 is more than that of 100KN/m^2 and 50KN/m^2.

According to fig.42, shows that as the Normal stress increases, the shearing stress of the soil reinforced with 0.25% Polypropylene fibre also increases. I did this test at three different normal stresses are 50KN/m^2, 100KN/m^2 and 150KN/m^2. The shear stresses corresponding to the normal stress are 61.5N/m^2,72.1KN/m^2 and 80.5KN/m^2.

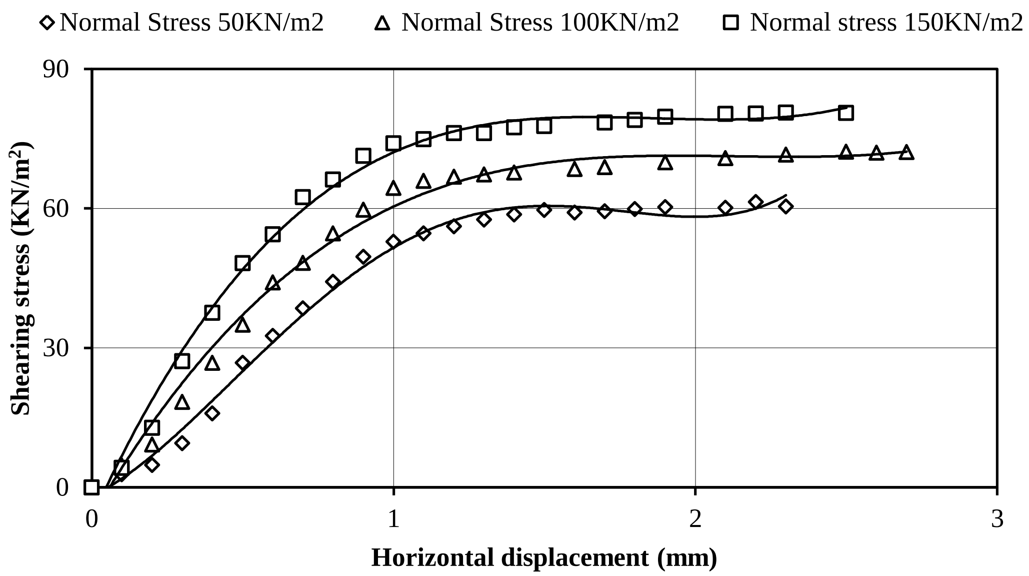

Fig.42: Variation of Shearing Stress with Horizontal displacement of soil reinforced with 0.25% Jute fibre at different Normal stress

This shear and normal stress is used to calculate the cohesion and angle of internal friction at 0.25% of fibre content.

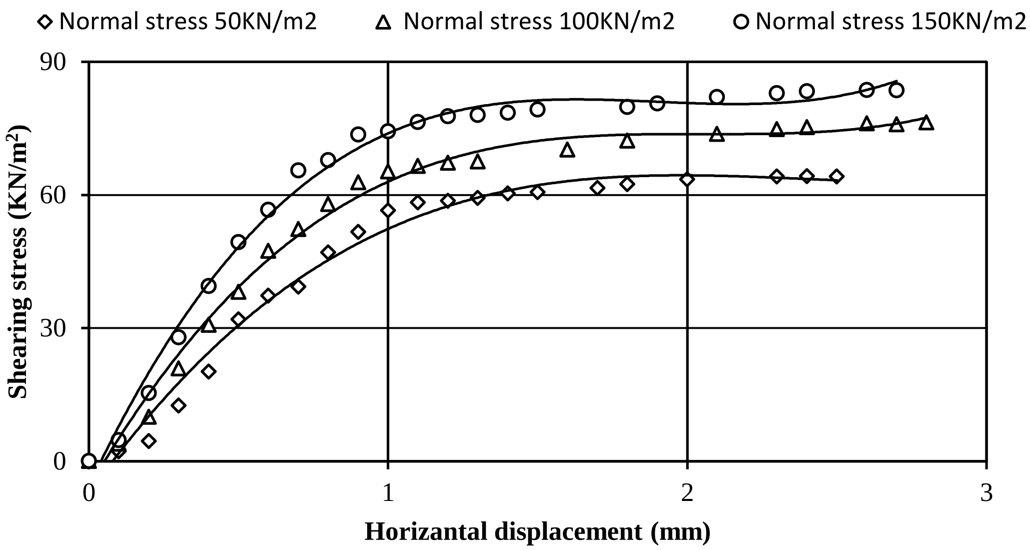

Fig.43: Variation of Shearing Stress with Horizontal displacement of soil reinforced with 0.50% Jute fibre at different Normal stress

According to fig.43, shows that as the Normal stress increases, the shearing stress of the soil reinforced also increases when it is reinforced with 0.50% Polypropylene fibre. I did this test at three different normal stresses are 50KN/m^2, 100KN/m^2 and 150KN/m^2. The shear stresses corresponding to the normal stress are 64.1KN/m^2,76.3KN/m^2 and

83.6KN/m^2. This shear stress and normal stress is used to calculate the cohesion and angle of internal friction at 0.50% of fibre content.

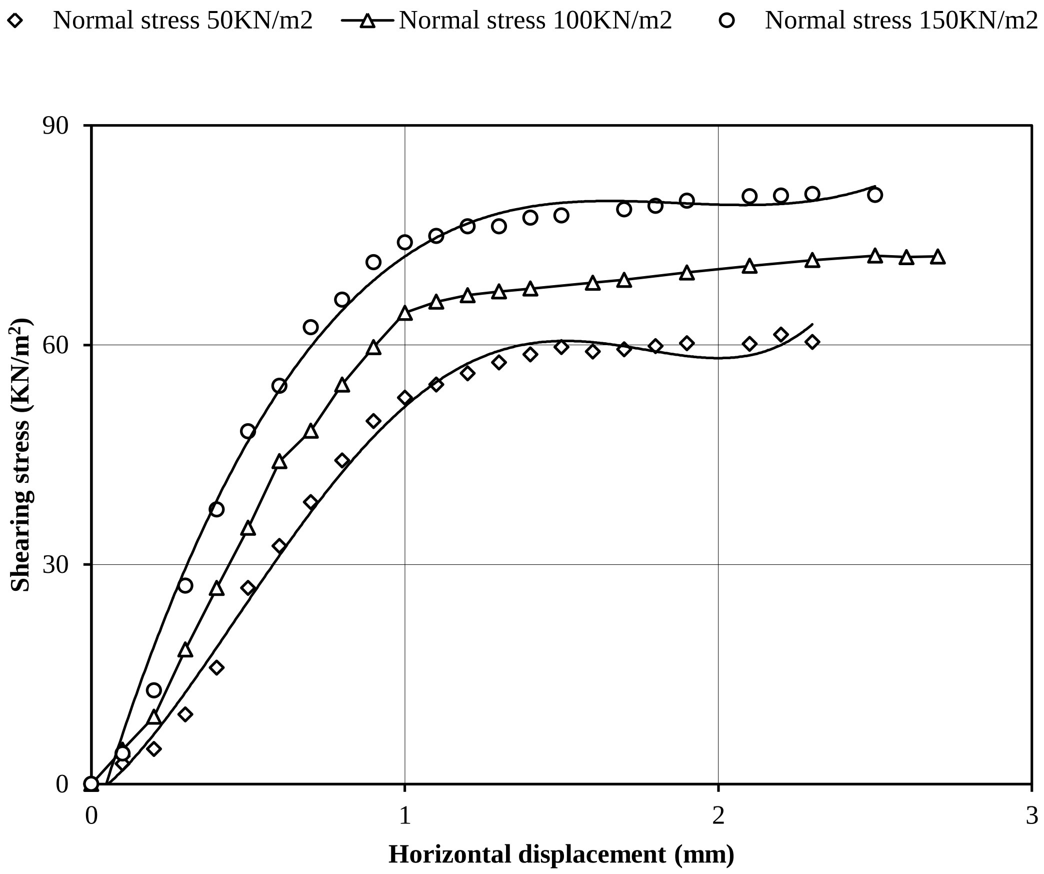

Fig.44: Variation of Shearing Stress with Horizontal displacement of soil reinforced with 0.75% Jute fibre at different Normal stress

According to fig.44, shows that as the Normal stress increases, the shearing stress of the soil reinforced also increases when it is reinforced with 0.75% Polypropylene fibre. I did this test at three different normal stresses are 50KN/m^2, 100KN/m^2 and 150KN/m^2. The shear stresses corresponding to the normal stress are 71.3KN/m^2,77.6KN/m^2 and 88.7KN/m^2. This shear stress and normal stress is used to calculate the cohesion and angle of internal friction at 0.75% of fibre content.

According to fig.45, shows that as the Normal stress increases, the shear strength of the soil reinforced also increases when it is reinforced with 1% Polypropylene fibre. I did this test at three different normal stresses that 50KN/m^2, 100KN/m^2 and 150KN/m^2.

The shear stress corresponding to the normal stress is 77.6KN/m^2,89.3KN/m^2 and 99.1KN/m^2.

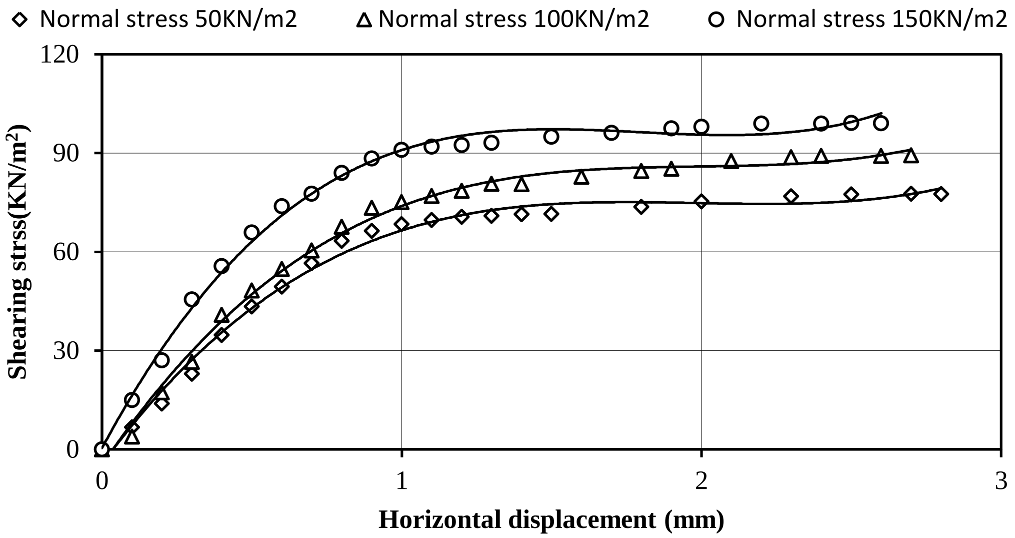

Fig.45: Variation of Shearing Stress with Horizontal displacement of soil reinforced with 1% Jute fibre at different Normal stress

This shear stress and normal stress is used to calculate the cohesion and angle of internal friction at 1% of fibre content.

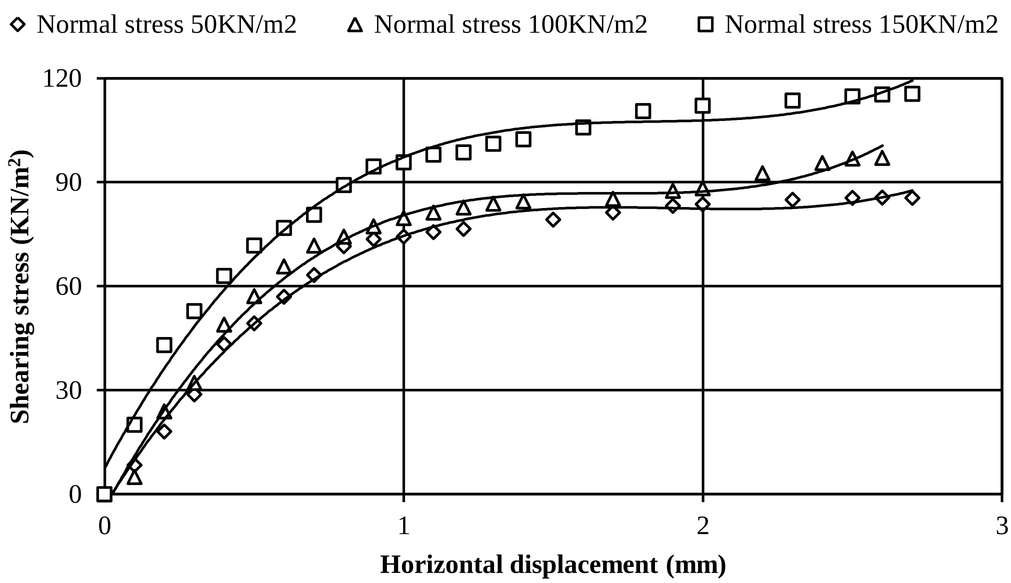

Fig.46: Variation of Shearing Stress with Horizontal displacement of soil reinforced with 1.25% Jute fibre at different Normal stress

According to fig.46, shows that as the Normal stress increases, the shearing stress of the soil reinforced also increases when it is reinforced with 1.25% Polypropylene fibre. I did this test at three different normal stresses are 50KN/m^2, 100KN/m^2 and 150KN/m^2. The shear stresses corresponding to the normal stress are 85.5KN/m^2,96.68KN/m^2 and 115.5KN/m^2. This shear stress and normal stress is used to calculate the cohesion and angle of internal friction at 1.25% of fibre content.

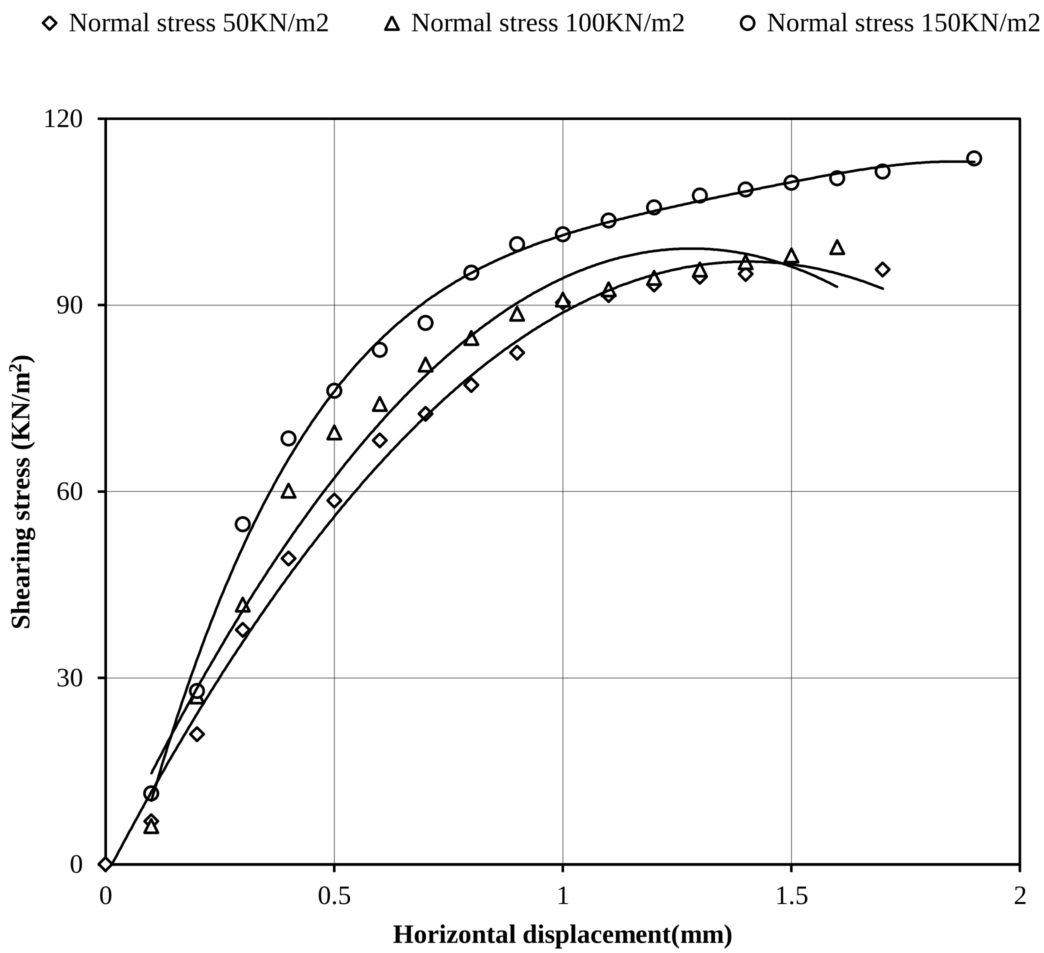

Fig.47: Variation of Shearing Stress with Horizontal displacement of soil reinforced with 1.50% Jute fibre at different Normal stress

According fig.47 shows that as the Normal stress increases, the shearing stress of the soil reinforced also increases when it is reinforced with 1.5% Polypropylene fibre. I did this test at three different normal stresses are 50KN/m^2, 100KN/m^2 and 150KN/m^2. The shear stresses corresponding to the normal stress are 99.4KN/m^2,104.5KN/m^2 and 117.1KN/m^2. This shear stress and normal stress is used to calculate the cohesion and angle of internal friction at 1.5% of fibre content. The Normal stress and shearing stress at different percentage of fibre are given below in table15.

Table.15: Shearing Stress & Normal Stress at different Percentage of Jute Fibre

Sample	Percent of Fibre	Normal stress (KN/m^2)	Shearing stress (KN/m^2)
Expansive soil	0	50	60.4
		100	71.8
		150	79.23
	0.25	50	61.4
		100	72.1
		150	80.5
	0.50	50	64.1
		100	76.3
		150	83.6
	0.75	50	71.3
		100	77.6
		150	88.7
	1	50	77.6
		100	89.3
		150	99.1
	1.25	50	85.5
		100	96.68
		150	115.5
	1.50	50	99.4
		100	104.5
		150	117.1

Table.15, Tells about the complete behavior of shearing stress at different percentage of fibre

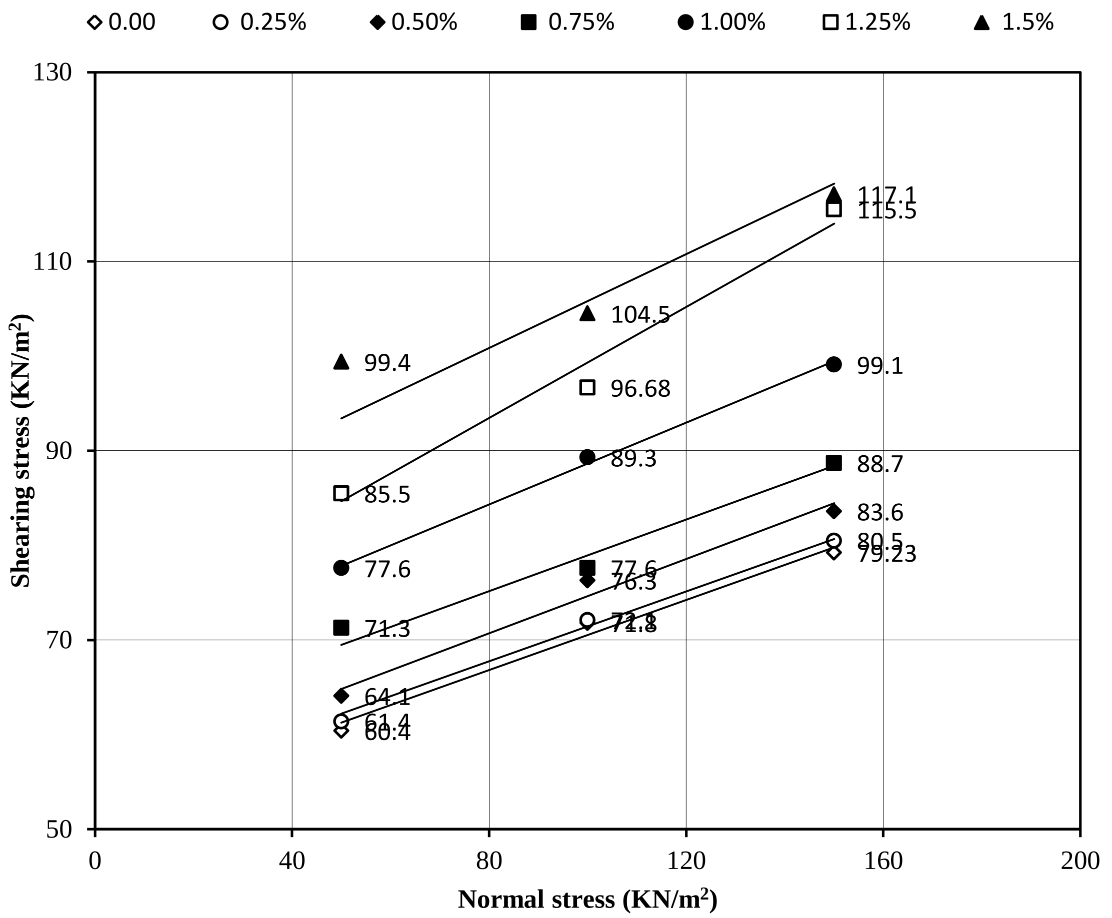

Fig.48: Variation of Shearing Stress with Normal Stress of soil reinforced with Jute Fibre in different Percentage

Table.16: Equation of Line, Slope & Intercept of line are at different Percentage of Jute Fibre

S.No.	Percent of fibre	Equation of line	$\emptyset = \tan^{-1}(Slope)$	Intercept (cohesion)KN /m²
1	0	Y=0.1853x+52	9.5	52
2	0.25	Y=0.1844x+53	10.4	53
3	0.50	Y=0.1964x+55	11.11	55
4	0.75	Y=0.1894x+60	10.72	60
5	1.00	Y=0.2164x+67	12.2	67
6	1.25	Y=0.2934x+70	16.4	70
7	1.50	Y=0.2481x+81	13.9	81

According to fig.48 and table .16, tells us about the cohesion and angle of internal friction of soil. Slope of the equation give the angle of internal friction and intercept give the cohesion of the soil. For 0%, 0.25%, 0.50%, 0.75%, 1.0%, 1.25% and 1.5% the value of cohesion is 52KN/m^2, 53KN/m^2, 55KN/m^2, 60KN/m^2, 67KN/m^2, 70KN/m^2 and 81KN/m^2 and angle of internal friction in degree 9.5, 10.4, 11.11, 10.72, 12.2, 16.4 and 13.9.

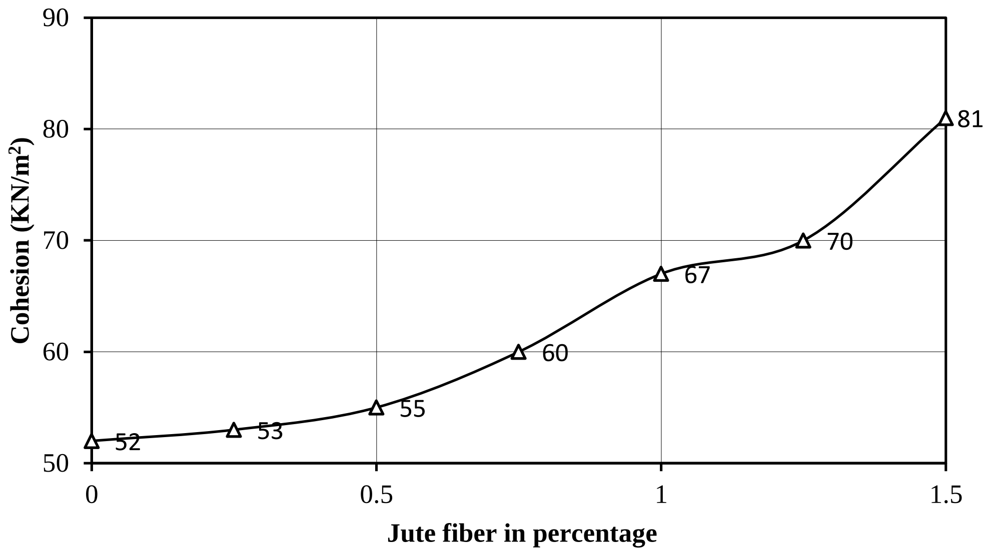

Fig.49: Variation of Cohesion with Jute Fibre in different Percentage

From the fig.49, it is find that for fibre content 0% to 0.50% and 1% to 1.25%, the cohesion value of the soil increases very less but for 0.50% to 1% and 1.25% to 1.5% it will increases sharply.

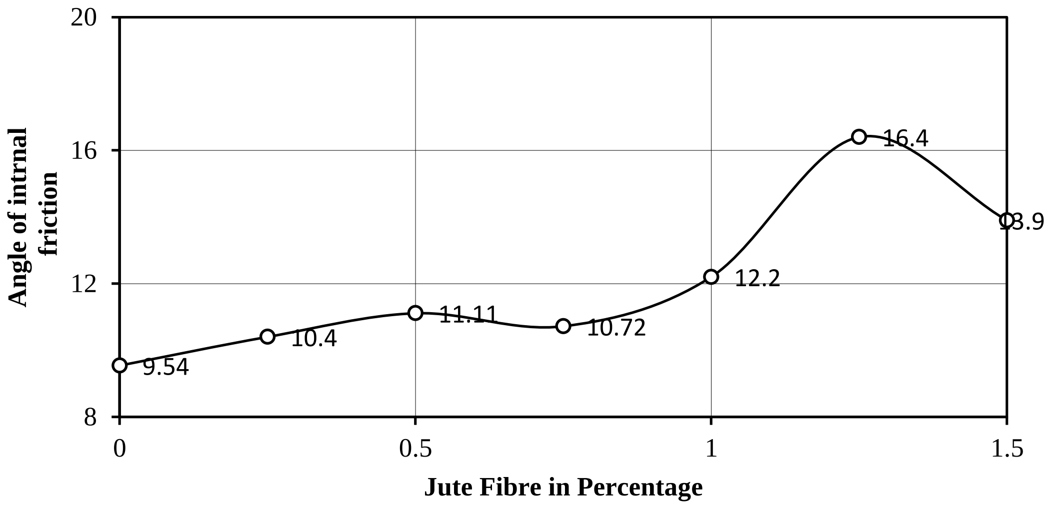

Fig.50: Variation of Angle of Internal Friction with Jute Fibre in different Percentage

From the fig.50, it was found that 0% to 0.50% and 0.75% to 1.25% the angle of internal friction increases sharply. For 0.5% to 0.75% and 1% to 1.5% it will decrease sharply.

4.3 SOIL REINFORCED WITH POLYPROPYLENE FIBRE

4.3.1 Proctor compaction test: IS: 10074(1982):

Sample weight=2.5Kg
Mass of mould +base plate (W) =4286gm
Volume of mould (V) =1000cc

According to fig.51 it is observed that as the fibre content increases from 0.25% to 1.5% it reduces the dry density of the soil and increases the optimum moisture content of soil.

This is because of replacement of higher density soil particle by lower density fibre. Also the increase of optimum moisture content is because the fibre has tendency to absorbed moisture from the soil.

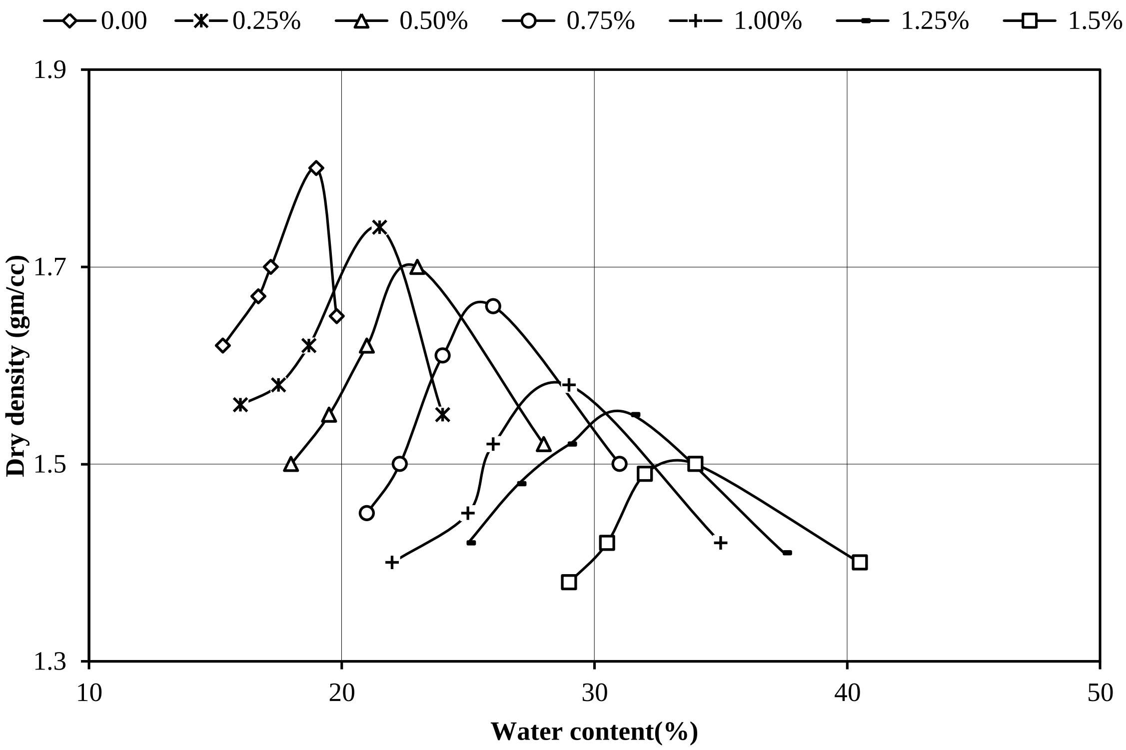

Fig.51: Variation of Dry density with water content of soil reinforced with different percentage of Polypropylene Fibre

The increases of optimum moisture content and decreases of maximum dry density along with different fibre content are given below in table.17:

Table.17: Variation of MDD and OMC with different Percentage of Fibre Content

S.No.	% of Polypropylene fibre	Maximum dry density(gm/cc)	Optimum moisture content (%)
1	0	1.8	19
2	0.25	1.74	21.5
3	0.50	1.7	23
4	0.75	1.66	26
5	1.0	1.58	29
6	1.25	1.55	31.5
7	1.5	1.5	34

Table.17 presents the result of OMC and MDD when expansive soil reinforced with Polypropylene fibre. Comparing the result with untreated soil it is observed that OMC increases by 21.5%, 23%, 26%, 29%, 31.5% and 34% and MDD decreases by 1.74gm/cc, 1.7gm/cc, 1.66gm/cc, 1.58gm/cc, 1.55gm/cc and 1.5gm/cc with respect to the untreated soil at fibre content of 0.25%, 0.50%, 0.75%, 1.0%, 1.25% and 1.5%.

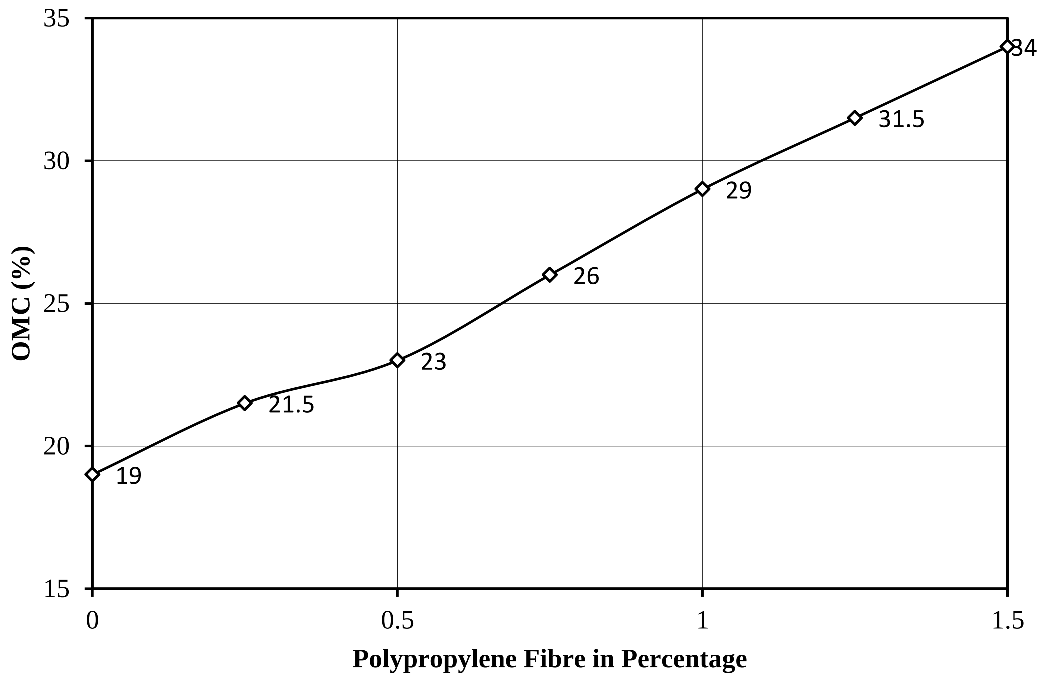

Fig.52: Variation of OMC with Polypropylene Fibre in different Percentage

From fig.52, it was found that as the fibre content increases from 0.25% to 1.5%, the optimum moisture content of the soil was increased linearly.

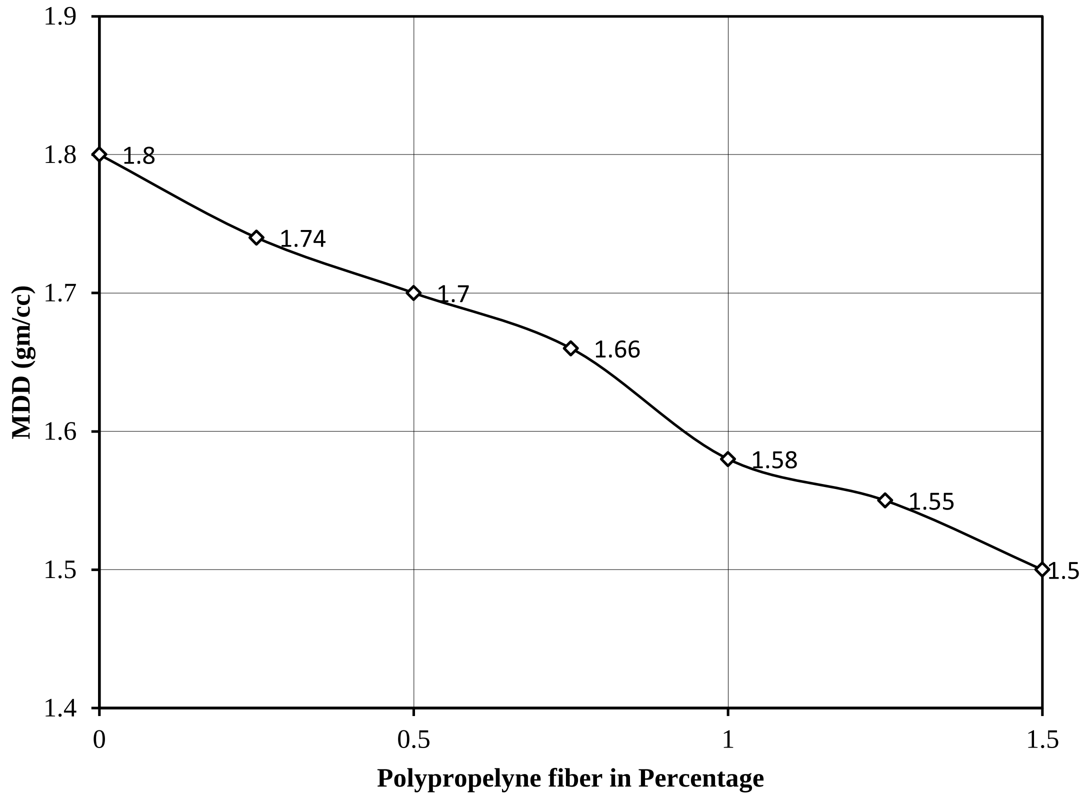

Fig.53: Variation of MDD with Polypropylene Fibre in Different Percentage

According to fig.53, it was found that as the fibre content increases from 0.25% to 1.5% the maximum dry density of the soil decreases.

4.3.2Unconfined compressive test IS: 2720(Part 10) (1987):

Optimum water content at different Percentage of fibre content
Mass of soil+ fibre=500gm
Dry density at different percentage of fibre content
Length of specimen=115mm
Diameter of specimen =50mm

According to fig.54, it was found that as the fibre content increases from 0.25% to 1.5%, the one day compressive strength of the expansive soil is increases up to the fibre content of 1.25% and further for 1.5% it will decreases. It means that the optimum value of fibre content to find the unconfined compressive strength for expansive soil is 1.25%.

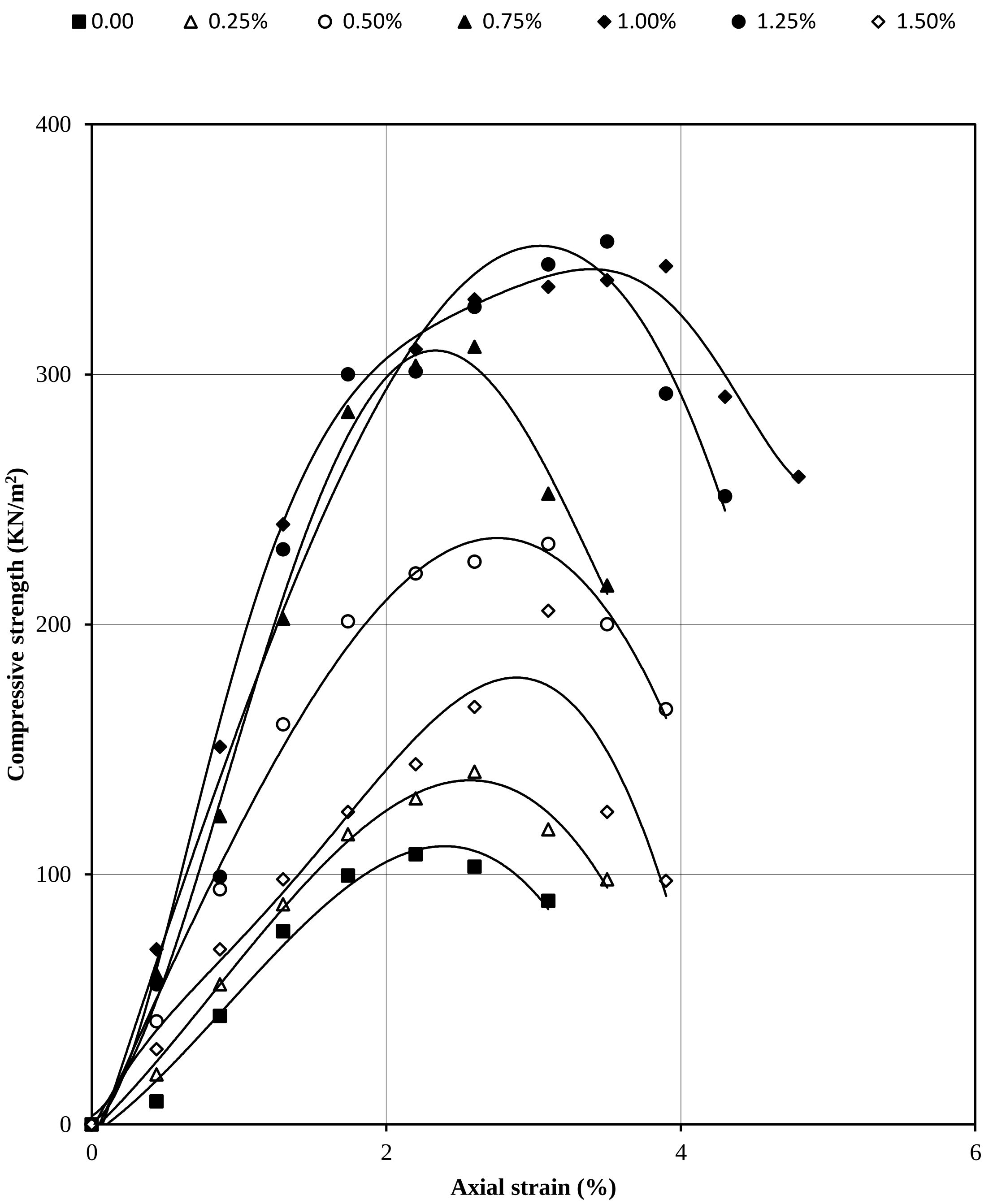

Fig.54: Variation of Compressive Strength with Axial Strain of soil reinforced with Polypropylene Fibre in different Percentage at 1 Day Curing Period

According to fig.55, it is found that as the fibre content increases from 0.25% to 1.5%, the Seven days compressive strength of the expansive soil is increases up to the fibre content of 1% and further from 1.25% to 1.5% it will decreases. It means that the optimum value of fibre content to find the unconfined compressive strength for Expansive soil is 1%.

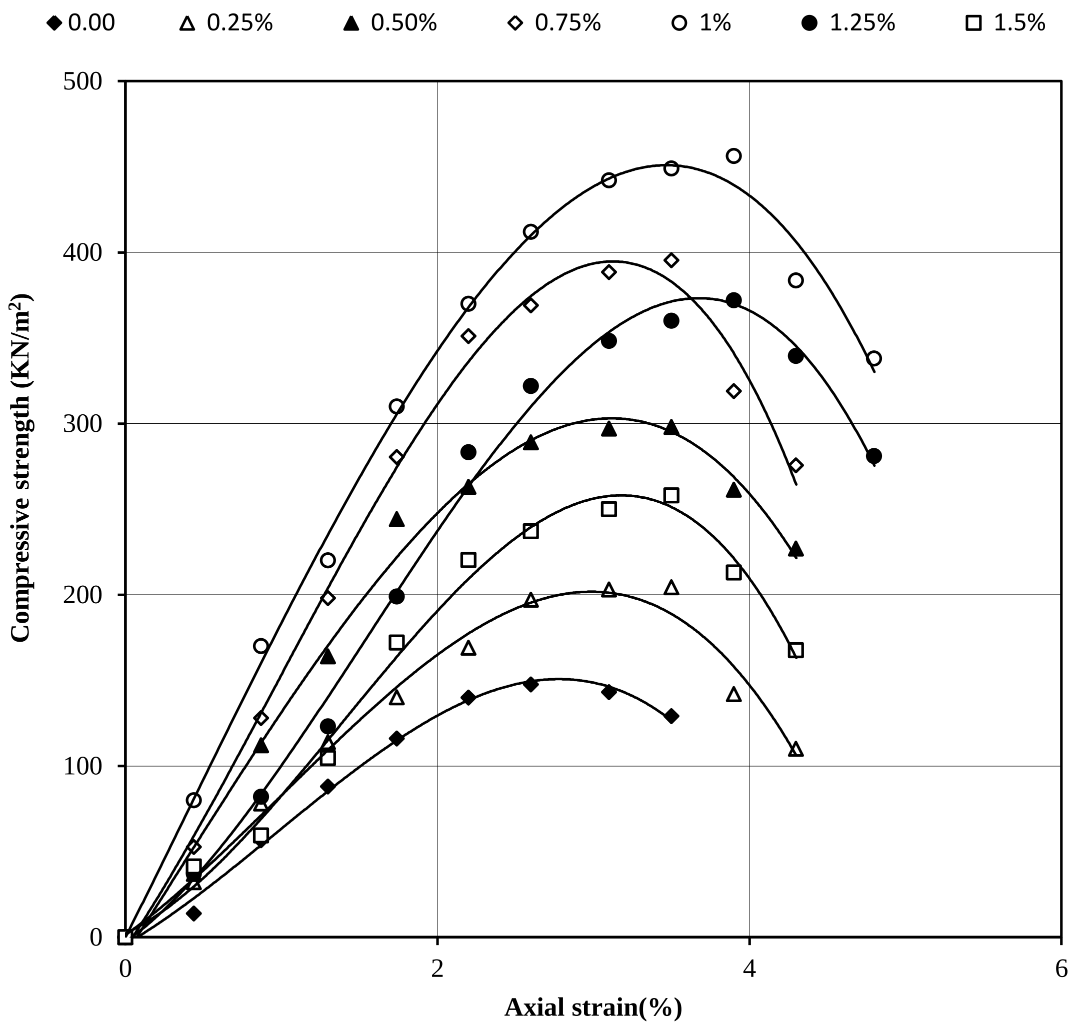

Fig.55: Variation of Compressive Strength with Axial Strain of soil reinforced with Polypropylene Fibre in different Percentage at 7 Days Curing Period

From the above discussion it is observed that 7 days compressive strength is more than that of one day at each stage of fibre content.

According to fig.56, it was found that as the fibre content increases from 0.25% to 1.5%, the 14 days compressive strength of the expansive soil increases up to the fibre content of 1% and further from 1.25% to 1.5% of it will decreases. It means that the optimum value of fibre content to find the unconfined compressive strength for Expansive soil is 1%.

But the 14 days compressive strength of expansive soil reinforced with Polypropylene fibre is more than that of 1and 7 days.

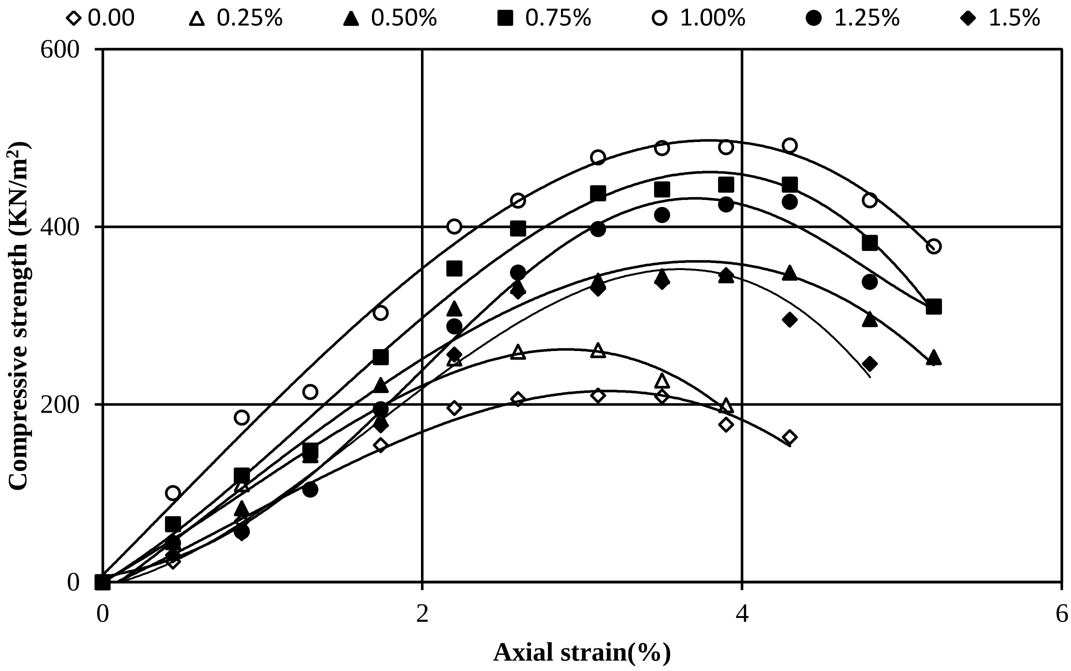

Fig.56: Variation of Compressive Strength with Axial Strain of soil reinforced with Polypropylene Fibre in different Percentage at 14 Days Curing Period

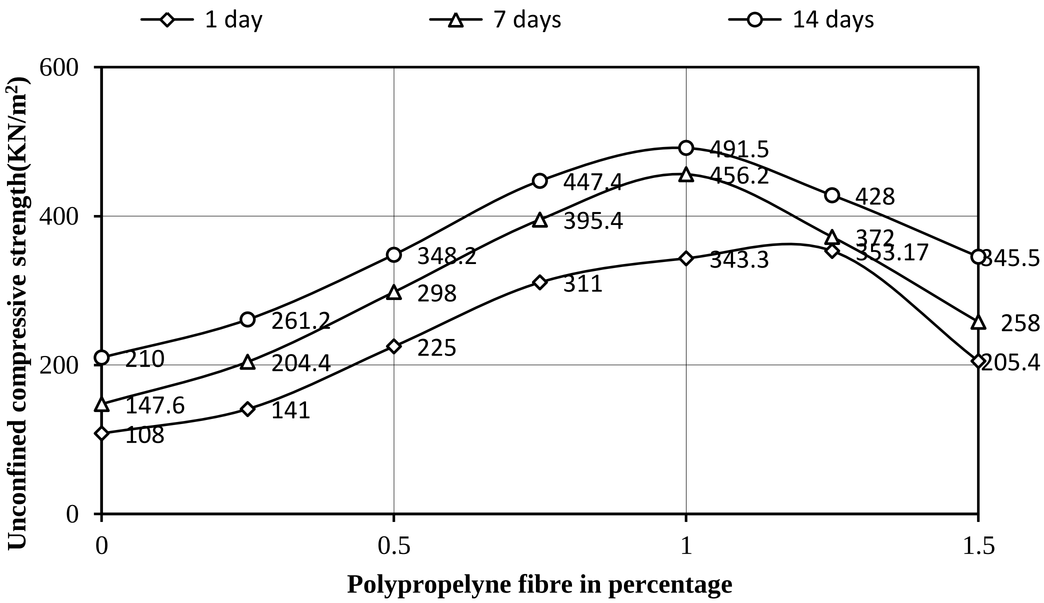

Fig.57: Variation of UCS with different Percentage of Polypropylene Fibre

According to fig.57, give the overall result of unconfined compressive strength of expansive soil reinforced with Polypropylene fibre at a fibre content of 0.25% to 1.5%. According to the fig.57 it was discussed that for one day curing period the unconfined compressive strength of soil increases up to the fibre content of 1.25% and for 7 days and 14 days curing it will increases up to 1% of fibre content and further it will decreased. The variation of unconfined compressive strength with fibre at curing period is given below in table-10.

Fig.58: Sample Prepared in Lab

Fig.59: Installation of Sample

Fig.60: Testing of Sample in Lab

Fig.61: Failure of Sample

Table.18: Unconfined Compressive Strength at different % of Polypropylene fibre at different Curing Period

Sample	**Curing days**	**Percent of fibre**	**Unconfined compressive strength(KN/m^2)**
Expansive soil	1days	0	108
		0.25	141
		0.50	225
		0.75	311
		1.00	343.3
		1.25	353.17
		1.50	205.4
	7 days	0	147.6
		0.25	204.4
		0.50	298
		0.75	395.4
		1.00	456.2
		1.25	372
		1.50	258
	14 days	0	210
		0.25	261.2
		0.50	348.2
		0.75	447.4
		1.00	491.5
		1.25	428
		1.50	345.5

According to the table.18, I found following result:

One day Unconfined compressive strength of expansive soil at 0%, 0.25%, 0.50%

,0.75% ,1.0% ,1.25% and 1.50% is 108KN/m^2, 141KN/m^2, 225KN/m^2, 311KN/m^2, 343.3KN/m^2, 353.17KN/m^2 and 205.4KN/m^2 and the percentage of variation of UCS with respect to soil is 31% ,108% ,188% ,218% ,227% and 90%.The maximum value of Unconfined compressive strength is 353.17KN/m^2 at fibre content of 1.25%

Seven days Unconfined compressive strength of expansive soil at 0%, 0.25%, 0.50%,0.75%,1.0%,1.25% and 1.50% is 147.6KN/m^2, 204KN/m^2, 298KN/m^2, 395.4KN/m^2, 456.2KN/m^2, 372KN/m^2 and 258KN/m^2 and the percentage of variation of UCS with respect to soil is ,38% ,102% ,168% ,209% ,152% and 75%.The maximum value of Unconfined compressive strength is 456.2KN/m^2 at fibre content of 1% .

Fourteen days Unconfined compressive strength of expansive soil at 0%, 0.25%, 0.50% ,0.75% ,1.0% ,1.25% and 1.50% is 210KN/m ,261.2KN/m^2,348.2KN/m^2, 447.4KN/m^2, 491.5KN/m^2, 428KN/m^2 and 345.5KN/m^2 and the percentage of variation of UCS with respect to soil is 24%, 66%, 113%, 134%, 104% and 65%. The maximum value of unconfined compressive strength is 491.5KN/m^2 at fibre content of 1%.

From the above discussion it is found that with increases the percentage of fibre and curing period the unconfined compressive strength of the soil increases but the percentage of variation of 7days and 14 days with respect to soil is less as compared to 1 day at different fibre content.

4.3.3California bearing ratio test (Unsoaked condition), IS: 2720(Part 1) (1987):

Optimum water content at different % of fibre Mass of mould=7950gm

Mass of soil=500gm Dry density at different % of fibre content

From the fig .62, it was observed that as the % of fibre content increases from 0.25% to 1.5%, the load carrying capacity of the expansive soil increases up to 1.25% of fibre content further it will decrease. It means that for California bearing ratio test the optimum percentage of fibre to calculate the test load is at 1.25%.

From the above discussion it is found that that increases in the load carrying capacity of expansive soil resulted in increases in the CBR value of the soil. It means this soil is safely used in sub grade, embankment.

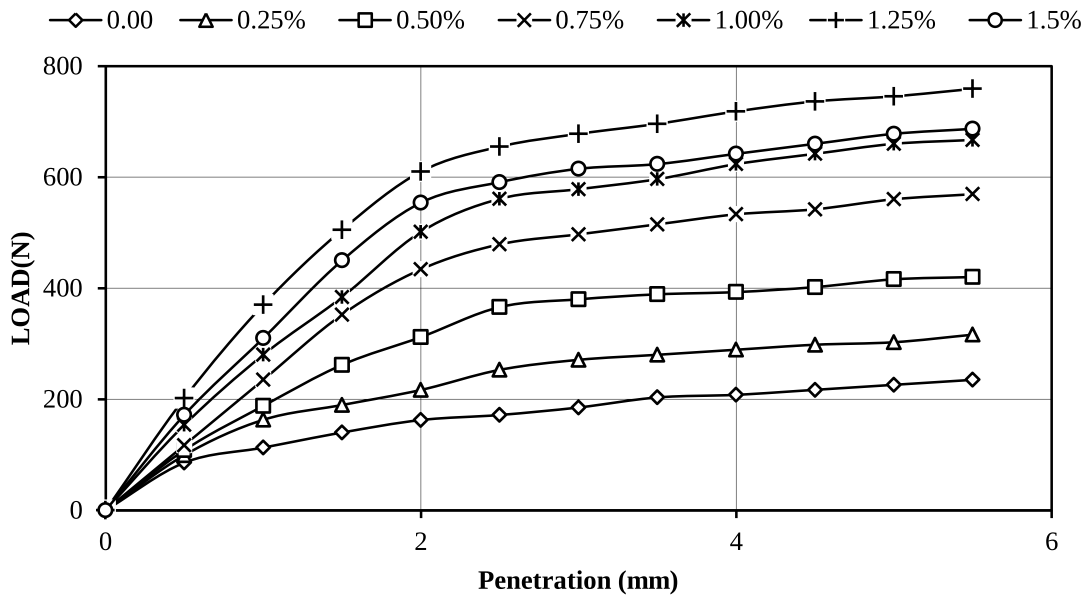

Fig.62: Variation of Load with Penetration of soil reinforced with different Percentage of Polypropylene Fibre

The reason to increases the value CBR can be explained by fig, 63. When the plunger pushes down the particle C, it tries to occupy the position in between particle A and B. The fibre resists the downward movement of particle C until there is slippage between the soil particle and fibre. We know that fibre cannot fail in tension and the slippage between the soil particle and fibre cannot occur. The interaction between the soil and fibre causes the resistance to the penetration of plunger resulting into higher value of CBR.

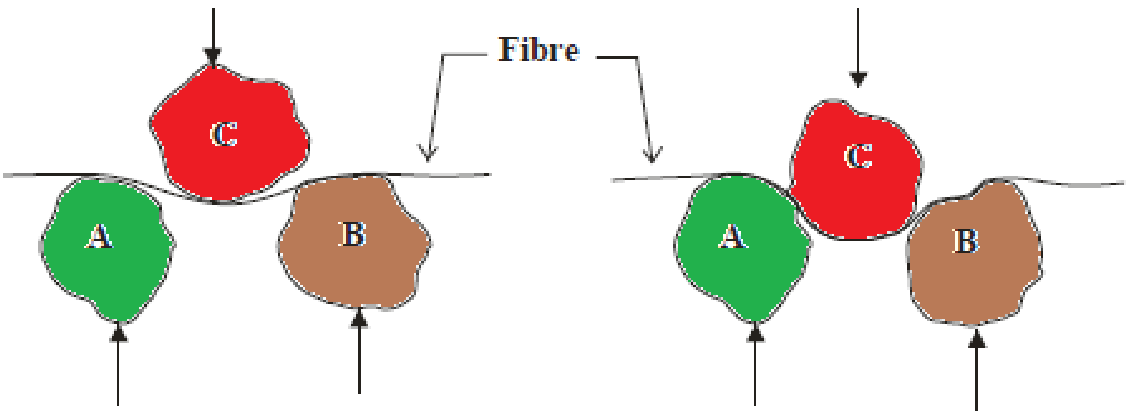

Fig.63: Soil Fibre Interaction

The other reason behind the increases in the CBR value is length of fibre. If longer length of fibre is used for reinforcement, the contact area of fibre with soil is more it will increases the value of CBR.

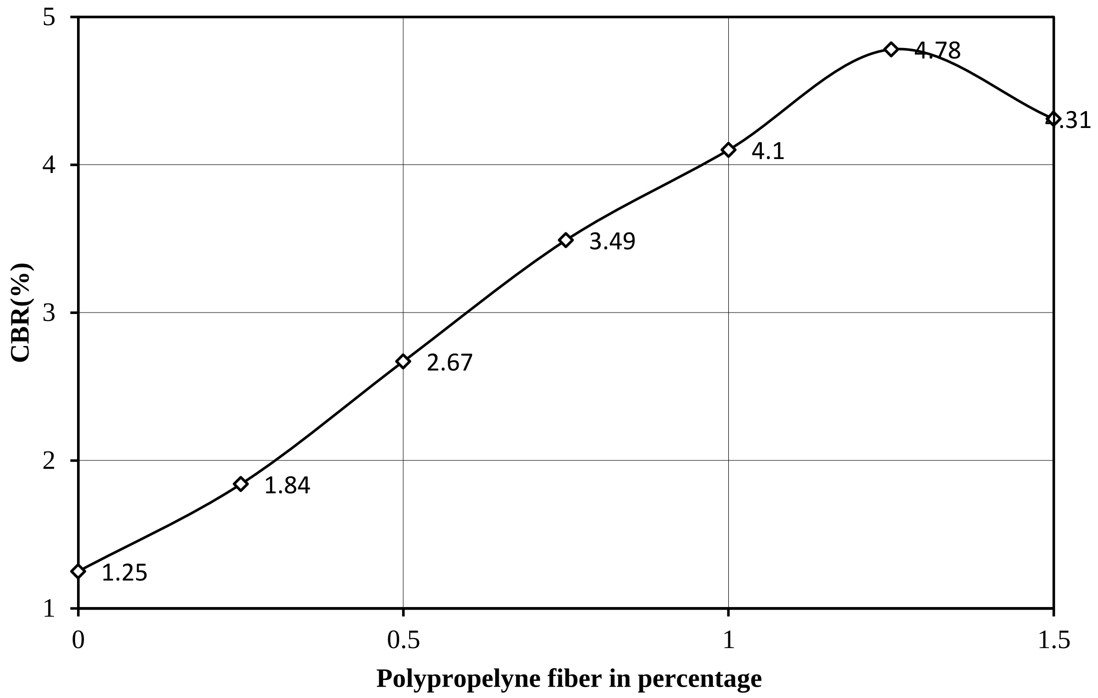

Fig.64: Variation of CBR with Polypropylene Fibre in Different Percentage

From the fig.64, it is found that the CBR value of the expansive soil is Increases up to 1.25% of Polypropylene fibre further it will decrease. It means that the optimum value of CBR at 1.25% of fibre content. The variation of CBR with Polypropylene fibre can be seen in table.19

Table.19: CBR value at different % of Polypropylene Fibre

S.No.	% of Polypropylene fibre	CBR(%)(Unsoaked condition)
1	0.00	1.25
2	0.25	1.84
3	0.50	2.67
4	0.75	3.49
5	1.00	4.1
6	1.25	4.78
7	1.50	4.31

Table .19, presents the result of CBR Test when expansive soil reinforced with Polypropylene fibre. When I compared the result with untreated soil, it is finding that inclusion of fibre causes significant improvement of CBR value. The CBR values are observed to be improved by 1.25%, 1.84%, 2.67%, 3.49%, 4.1%, 4.78% and 4.15% at fibre content of 0.25%, 0.50%, 0.75%, 1.0%, 1.25% and 1.5%.

The percentage of increase in the CBR value are observed by 47.2%, 113%, 179.2%, 230.6%, 282.4% and 232% with respect to untreated soil.

4.3.4 Free swell index, IS: 2720 (part XL) (1977):

Free swell index is determined by IS specification. According to the experimental investigation it is found that as the fibre content increases from 0.25% to 1.5% the free swell index of the soil decreases.

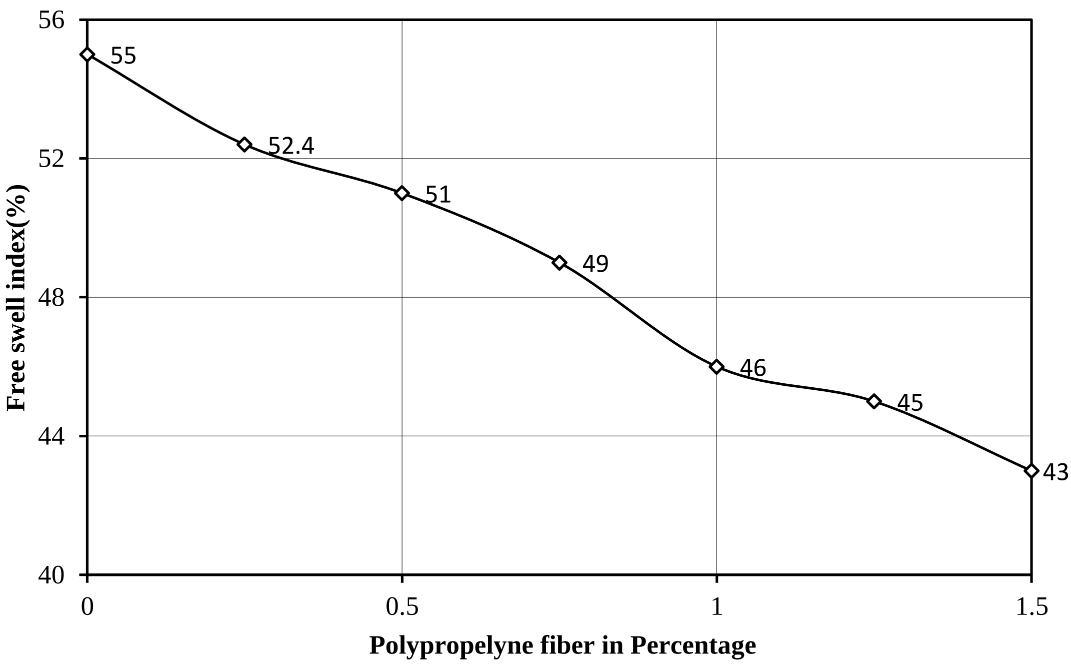

Fig.65: Variation of Free Swell index with Polypropylene Fibre in different Percentage

According to fig.65, it was found that from 0.25% to 1.5% of fibre content the free swell index of the soil is decreases sharply. This decrease in the value of free swell is good for soil.

The reason for decreasing the free swell index is that when the water in contact with soil-fibre mixture, fibre absorbs moisture and there is very less amount of water in contact with soil so due to this the swelling action of the soil decreases.

This test is conducted before designing of dams, embankment, and canals like structure which is built up on expansive soil because there is excess amount of seepage of water in that structure due to this there is chance of failure of structure. The decrease of free swell index shown in table 20

Table.20: Free Swell Index at different value of Polypropylene fibre

S.No.	% of Polypropylene fibre	Free Swell Index (%)
1	0	55
2	0.25	52.4
3	0.50	51
4	0.75	49
5	1.0	46
6	1.25	45
7	1.5	43

Table.20, presents the result of free swell index when the soil is reinforced with fibre. When I compared the result with untreated soil it was found that there is an improvement of soil with increases of fibre content. Free swell index values are observed to be decreased by 55%, 52.4%, 51%, 49%, 46%, 45% and 43% at fibre content of 0%, 0.25%, 0.50%, 0.75%, 1.0%, 1.25% and 1.5%.

4.3.5 Indirect tensile strength test (Brazilian test), IS: 10082(1982):

Optimum water content at different Percentage of fibre content

Mass of soil+ fibre=500gm
Dry density at different percentage of fibre content
Length of specimen=100mm
Dia. of specimen =50mm

The study of the tensile strength of the soil is very important factor because many structures were damaged due to the tensile forces. So the following result find out by doing this test to study the behaviour of the soil in tension, so according to investigation it will be find out that the tensile strength of the soil is very less and there is an need of improvement.

From fig.66, it was observed that as the fibre content increases from 0.25% to 1.5%, the tensile strength of the Expansive soil is increased. The increase in tensile strength of the soil up to the fibre content of 1% and further it will decrease for both 7 days and 14 days curing period. But the tensile strength of 14 days curing period is more than that of 7 days curing period.

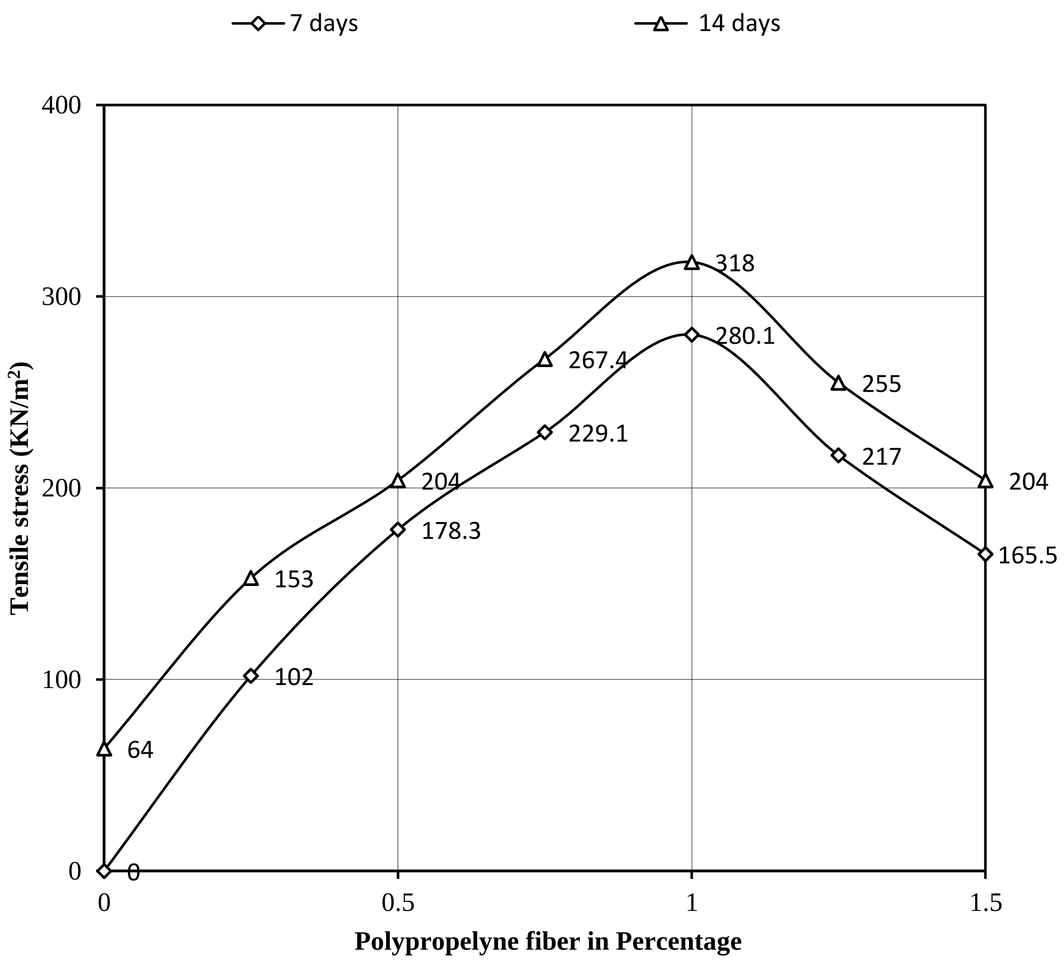

Fig.66: Variation of tensile strength with Polypropylene Fibre reinforced in soil at different days of curing

The reason to increase the tensile strength of soil is fibre, because fibre works like a reinforcement, it is a randomly distributed with soil, we all know that fibre the tenacity of the fibre is more than that of soil, So due to this property of the fibre it increases the tensile strength of the soil. We can think that the fibre works with soil is same as steel works in concrete. This test has much importance where the failure of the structure is due to tensile stress. Before constructing the dams, a canal, building this test is very useful to predict the tensile strength of soil. The tensile strength of the soil at 7 days and 14 days curing period are given below in table21:


Fig.67: Placing of Sample in Rock Lab


Fig.68: Failure of Sample at 7 days curing


Fig.69: Complete Failure at 14 days


Fig.70: Pressing of Sample

Table.21: Tensile Strength of Soil Reinforced with Polypropylene Fibre at different Curing Period

Sample	**Curing days**	**Fibre (%)**	**Tensile strength(KN/m^2)**
Expansive soil	7 days	0	0
		0.25	102
		0.50	178.3
		0.75	229.1
		1.0	280.1
		1.25	217
		1.5	165.5
	14 days	0	64
		0.25	153
		0.50	204
		0.75	267.4
		1.00	318
		1.25	255
		1.50	204

Table.21, presents the tensile strength of the soil when it is reinforced with Polypropylene fibre. When I compare the result with untreated soil then I found that the tensile strength of the soil was improved.

The 7 days tensile strength of the soil was increased by 0KN/m^2, 102KN/m^2, 178.3KN/m^2, 229.1KN/m^2, 280.1KN/m^2, 217KN/m^2, and 165KN/m^2, when it is reinforced with 0%, 0.25%, 0.50%, 0.75%, 1.00%, 1.25% and 1.5% Polypropylene fibre.

The 14 days tensile strength of the soil was increased by 64KN/m^2, 153KN/m^2, 204KN/m^2, 267.4KN/m^2, 318KN/m^2, 255KN/m^2 and 204KN/m^2 when it was reinforced with 0%, 0, 25%, 0.50%, 0.75%, 1.00%, 1.25% and 1.5% Polypropylene fibre.

4.3.6 Direct shear test, IS: 2720(Part 11) (1983):

Size of box=6cmx6cmx3cm Area of box=36cm^2

Mass of box + base plate + porous stones +grid plate=3250gm

Mass of box +base plate + porous stones +grid plate +soil specimen+ fibre=3500gm

Normal stress=50KN/m^2, 100KN/m^2, 150KN/m^2

According to the fig .71, above it is clearly observed that as the fibre content increases from 0.25% to 1.5%the shearing stress of the soil increases as compared to untreated soil when the applied Normal load is 50KN/m^2. Fibre content of 0.25% to 0.75% the shearing stress of the soil increases sharply for all value of shear displacement but as we move further from 0.75% to 1.5% the increases of shearing stress value is very less so all the curve very close to each other

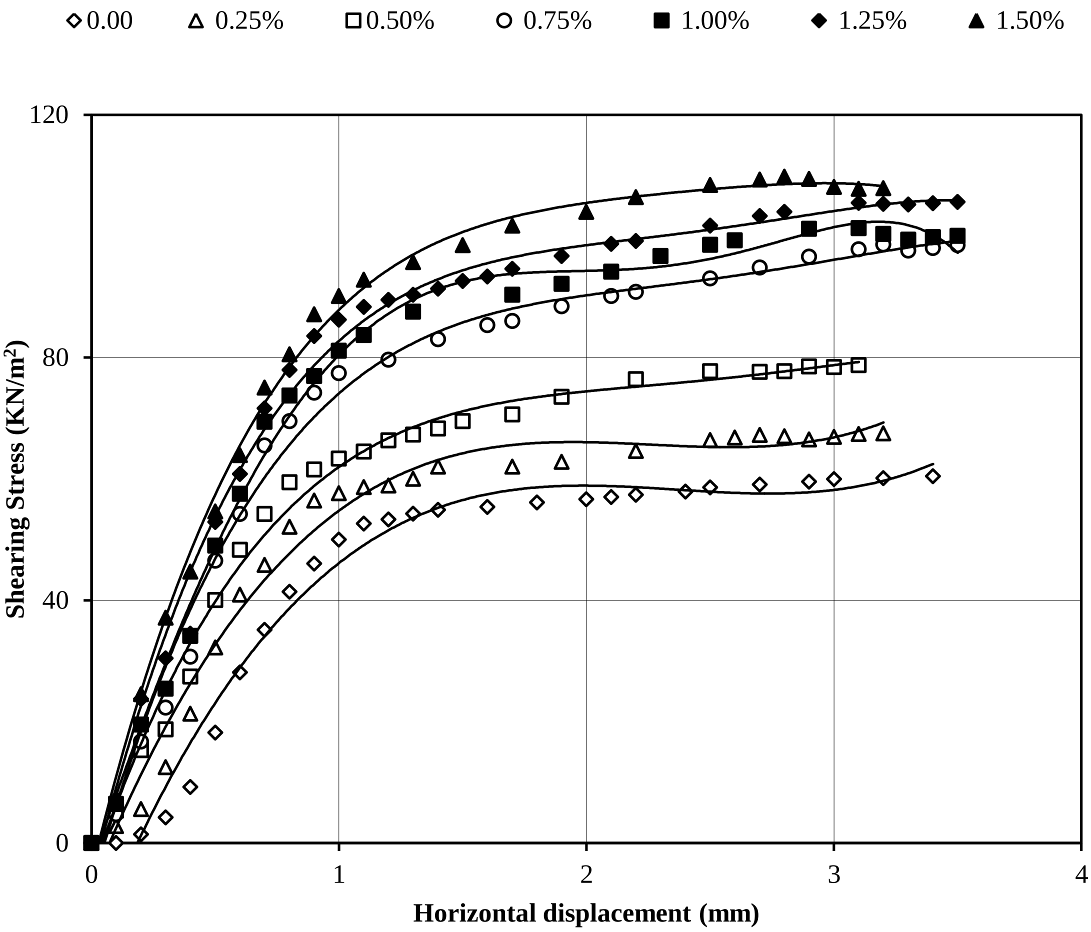

Fig.71: Variation of Shearing stress with horizontal displacement of Soil reinforced with Polypropylene Fibre at Normal Stress 50KN/m

According to the fig.72, it was observed that as the fibre content increases, the shearing strength of the soil increases when the applied normal load is 100KN/m^2. I studied the fig.72 and found that for 0.25% fibre content the shearing stress curve is close to untreated soil but as we move further, the shearing stress curve is far apart at 0.50% fibre content .It means that at this percentage the shearing stress of the soil for all value of horizontal displacement increases sharply as compared to 0.25% fibre content. As we move further from1% to 1.5% the shearing stress curve is very close to each other it means that for this percentage the increases of shear stress for all shear displacement is very less.

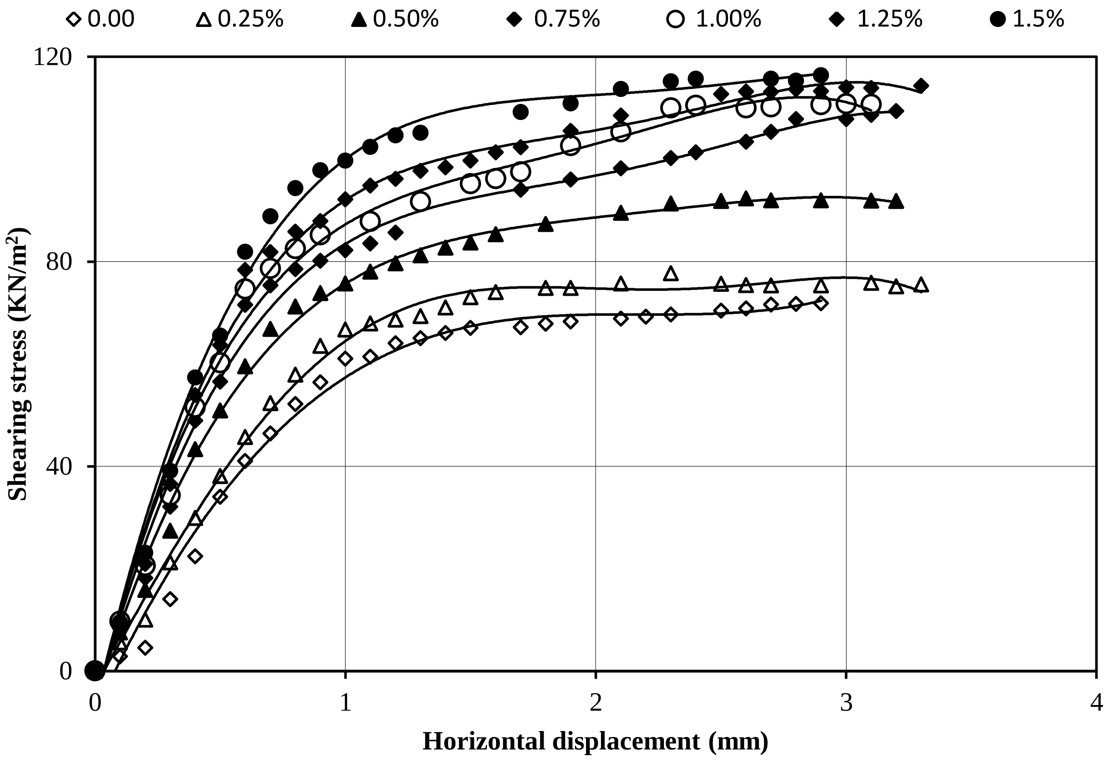

Fig.72: Variation of Shearing stress with horizontal displacement of Soil reinforced with Polypropylene Fibre at Normal Stress 100KN/m^2

From the figure 72 it is clearly noticed that the shearing stress value at 100KN/m^2 is more than that of 50KN/m^2 at each stage of fibre content for all values of horizontal shear displacement

According to the fig.73, it was observed that as the fibre content increase the Shearing stress value for all value of horizontal displacement increases. Fig shows that from 0.25% to 0.75% fibre content shearing stress curve is far apart to untreated soil, it means in this % the shearing stresses increases sharply, but if I studied further from 0.75% to 1.5% the shearing stress curves are very close. It means in this range the increases in the value of shearing stress for all horizontal displacement is very less.

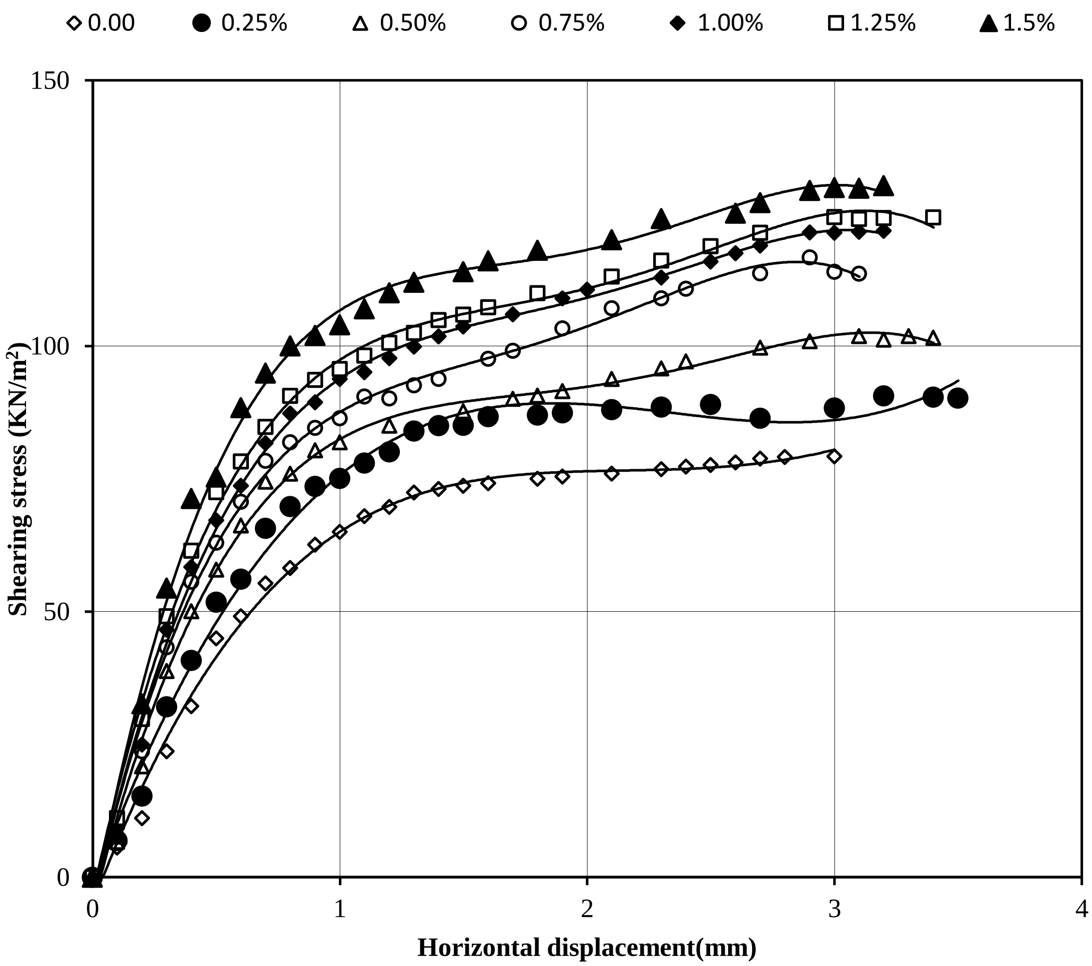

Fig.73: Variation of Shearing stress with horizontal displacement of Soil reinforced with Polypropylene Fibre at Normal Stress 150KN/m^2

The shearing stress value correspondence to all horizontal shear displacement at 150KN/m^2 is more than that of 100KN/m^2 and 50KN/m^2.

According to fig.74, shows that as the Normal stress increases, the shearing stress of the soil reinforced with 0.25% Polypropylene fibre also increases. I did this test at three different normal stresses are 50KN/m^2, 100KN/m^2 and 150KN/m^2. The shear stresses corresponding to the normal stress are 67.5KN/m^2,75.5KN/m^2 and 90.2KN/m^2.

This shear stress and normal stress is used to calculate the cohesion and angle of internal friction at 0.25% of fibre content.

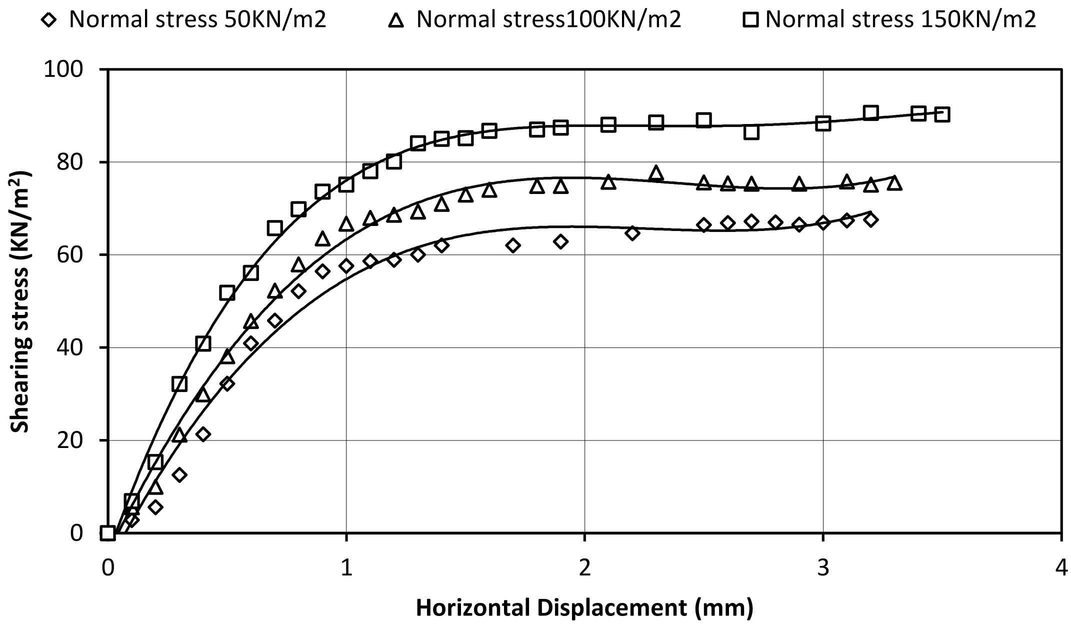

Fig.74: Variation of Shearing Stress with Horizontal displacement of soil reinforced with 0.25% Polypropylene fibre at different Normal stress

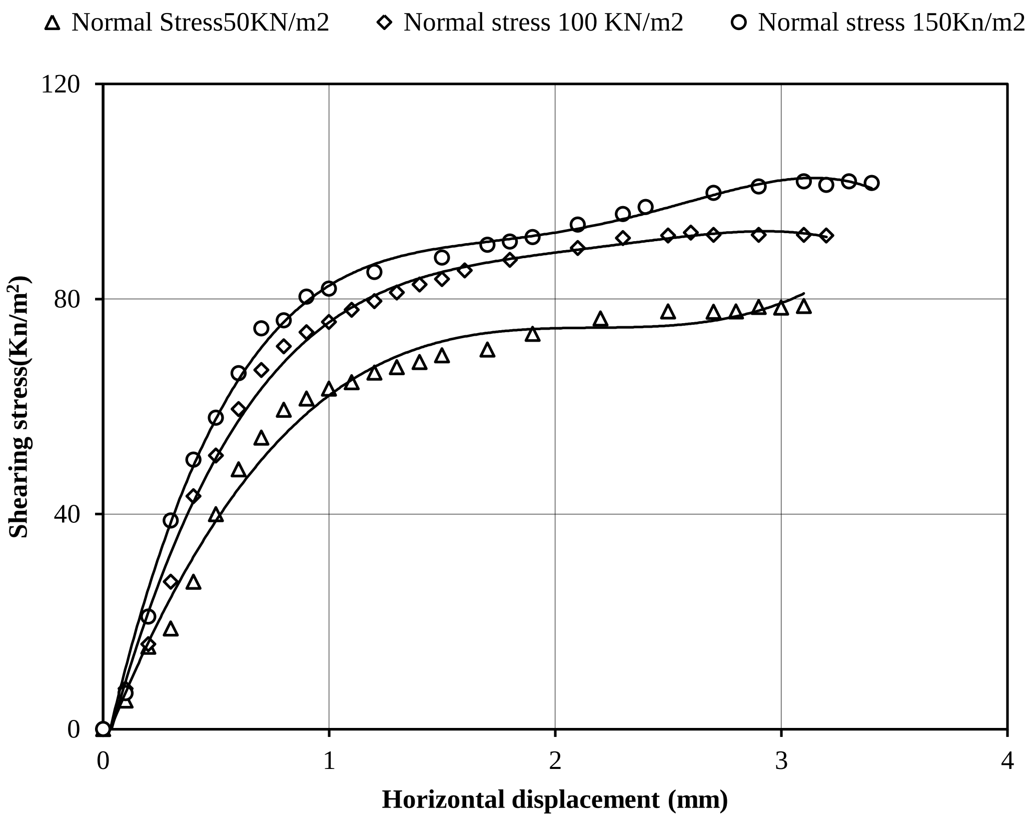

Fig.75: Variation of Shearing Stress with Horizontal displacement of soil reinforced with 0.50% Polypropylene fibre at different Normal stress

According to fig.75, shows that as the Normal stress increases, the shearing stress of the soil also increases when it is reinforced with 0.50% Polypropylene fibre. I did this test at three different normal stresses are 50KN/m^2, 100KN/m^2 and 150KN/m^2. The shear stresses corresponding to the normal stress are 78.7KN/m^2,91.8KN/m^2 and 101.9KN/m^2. This shear stress and normal stress is used to calculate the cohesion and angle of internal friction at 0.50% of fibre content.

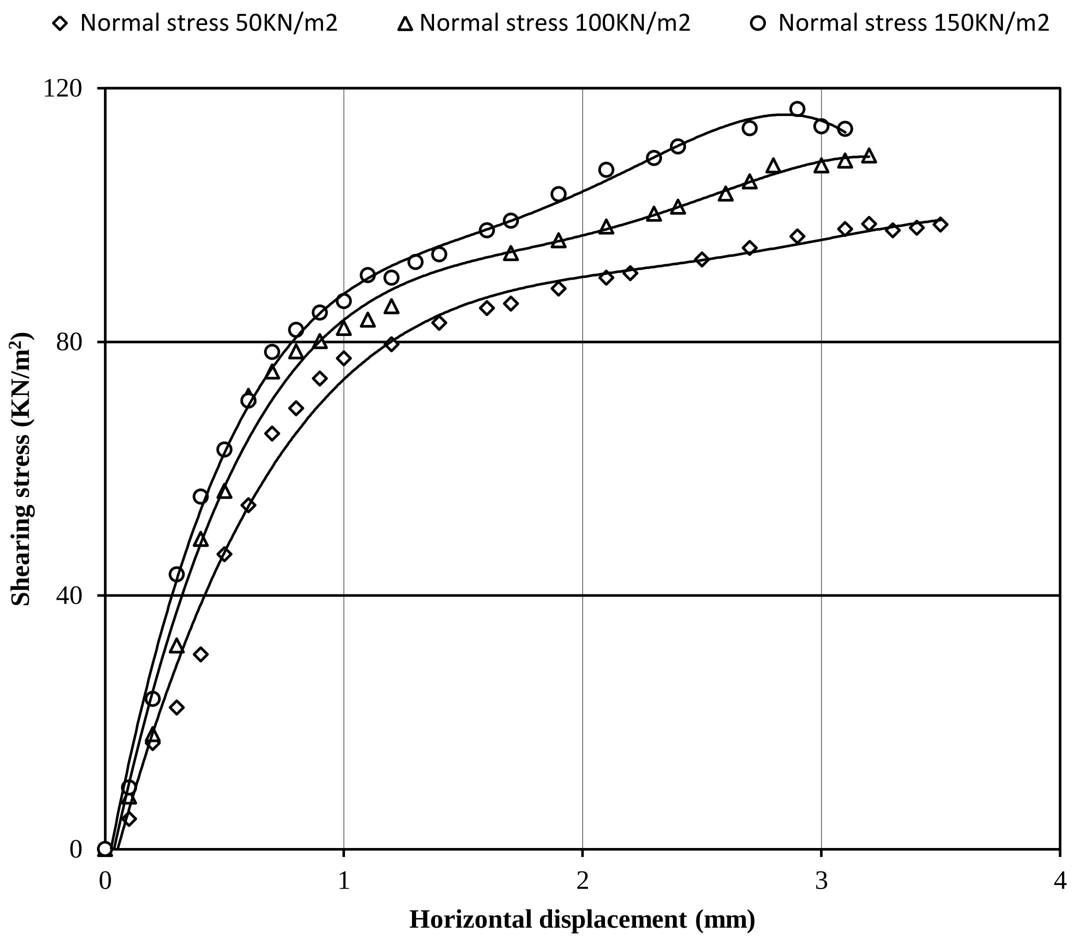

Fig.76: Variation of Shearing Stress with Horizontal displacement of soil reinforced with 0.75% Polypropylene fibre at different Normal stress

According to fig.76, shows that as the Normal stress increases, the shearing stress of the soil also increases when it is reinforced with 0.75% Polypropylene fibre. I did this test at three different normal stresses are 50KN/m^2, 100KN/m^2 and 150KN/m^2. The shear stresses corresponding to the normal stress are 98.5KN/m^2,109.4KN/m^2 and 116.7KN/m^2. This shear stress and normal stress is used to calculate the cohesion and angle of internal friction at 0.75% of fibre content.

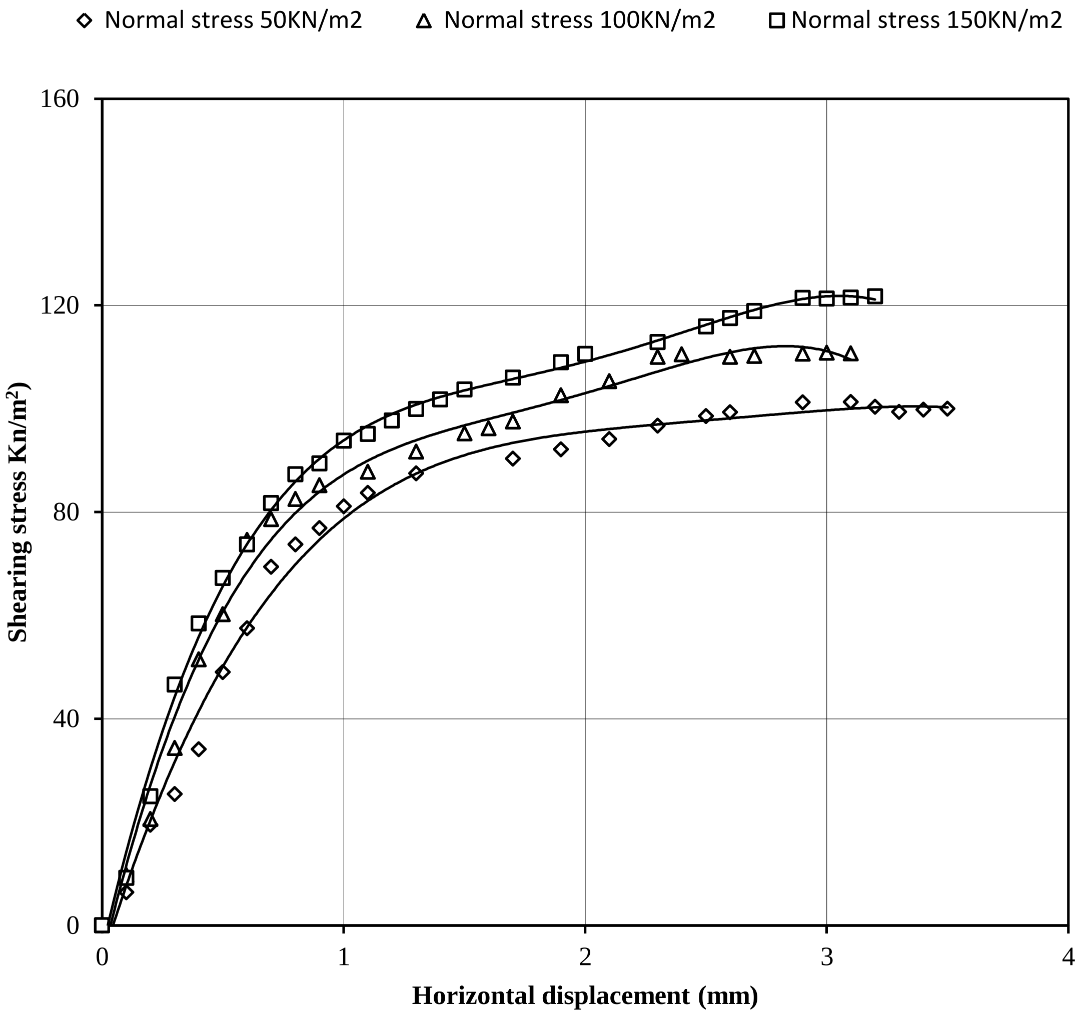

Fig.77: Variation of Shearing Stress with Horizontal displacement of soil reinforced with 1.00% Polypropylene fibre at different Normal stress

According fig .77 shows that as the Normal stress increases, the shearing stress of the soil also increases when it is reinforced with 1% Polypropylene fibre. I did this test at three different normal stresses are 50KN/m^2, 100KN/m^2 and 150KN/m^2. The shear stresses corresponding to the normal stress are 101.3KN/m^2,110.8KN/m^2 and 121.7KN/m^2. This shear stress and normal stress is used to calculate the cohesion and angle of internal friction at 1% of fibre content.

According to fig.78, shows that as the Normal stress increases, the shearing stress of the soil also increases when it is reinforced with 1.25% Polypropylene fibre. I did this test at three different normal stresses are 50KN/m^2, 100KN/m^2 and 150KN/m^2. The shear stresses corresponding to the normal stress are 105.6KN/m^2,114.3KN/m^2 and

124.3KN/m^2. This shear stress and normal stress is used to calculate the cohesion and angle of internal friction at 1.25% of fibre content.

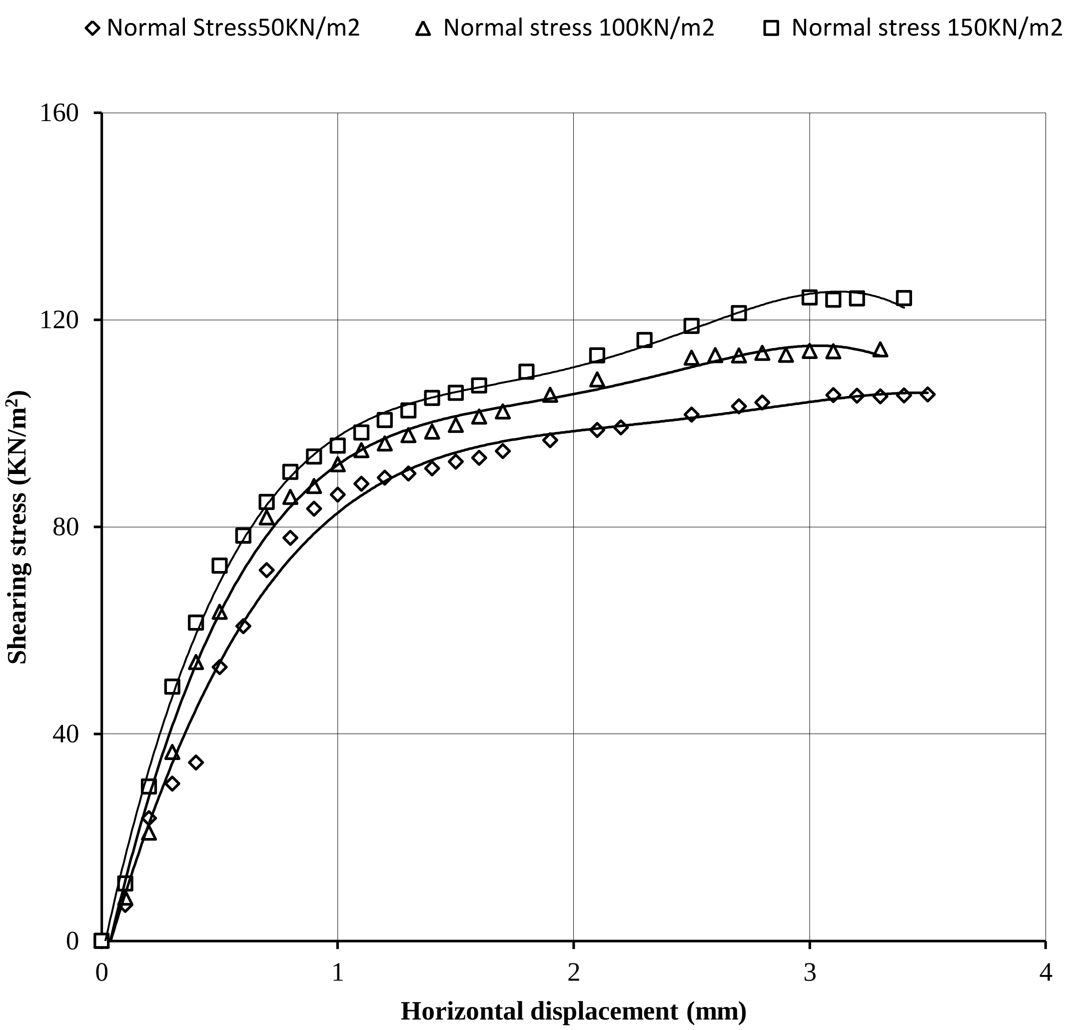

Fig.78: Variation of Shearing Stress with Horizontal displacement of soil reinforced with 1.25% Polypropylene fibre at different Normal stress

According to fig.79, shows that as the Normal stress increases, the shearing stress of the soil also increases when it is reinforced with 1.5% Polypropylene fibre. I did this test at three different normal stresses are 50KN/m^2, 100KN/m^2 and 150KN/m^2. The shear stresses corresponding to the normal stress are 109.8KN/m^2,116.4KN/m^2 and 131.2KN/m^2. This shear stress and normal stress is used to calculate the cohesion and angle of internal friction at 1.5% of fibre content.

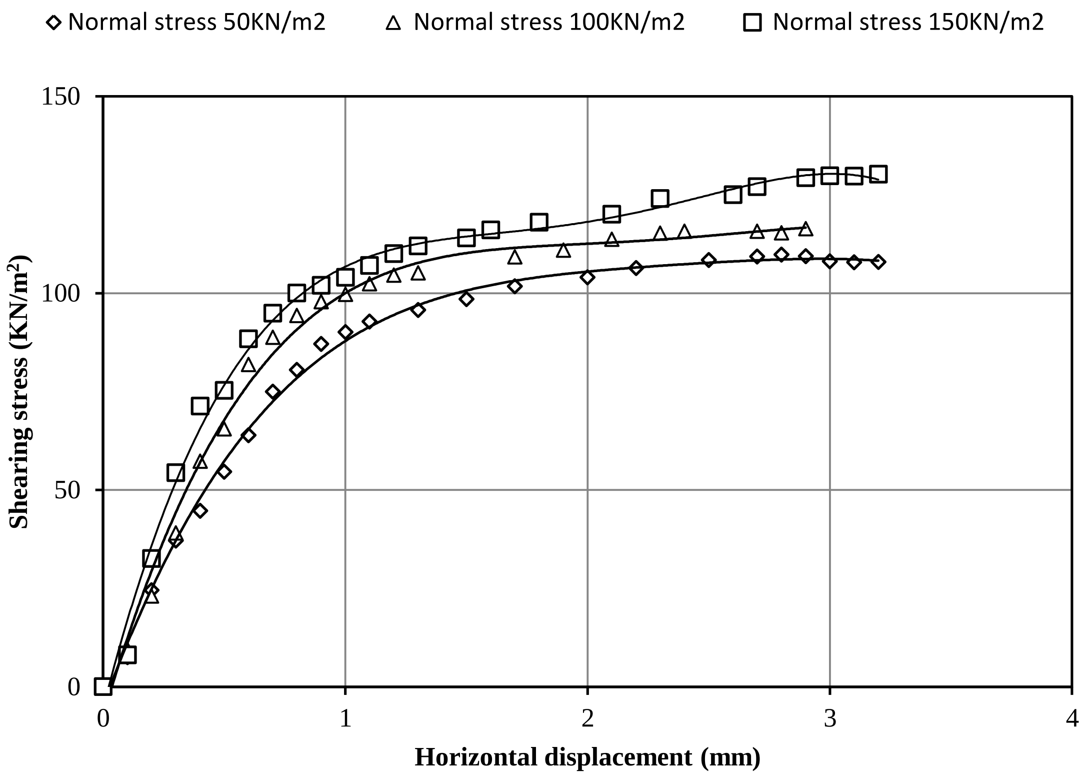

Fig.79: Variation of Shearing Stress with Horizontal displacement of soil reinforced with 1.50% Polypropylene fibre at different Normal stress

The Normal stress and shearing stress at different percentage of fibre are given below in table 22.

Table.22: Shearing Stress & Normal Stress at different Percentage of Polypropylene Fibre

Sample	Percent of Fibre	Normal stress(KN/m^2)	Shearing stress(KN/m^2)
	0	50	60.4
		100	71.8
		150	79.23
	0.25	50	67.5
		100	75.5
		150	90.2
	0.50	50	78.7

Epansive soil		100	91.8
		150	101.9
	0.75	50	98.5
		100	109.4
		150	116.7
	1	50	101.3
		100	110.8
		150	121.7
	1.25	50	105.6
		100	114.3
		150	124.3
	1.50	50	109.8
		100	116.4
		150	131.2

This Table .22, tells about the complete behavior of shearing stress at different percentage of fibre

Fig.80: Sample in Direct Shear Box

Fig.81: Failure of Sample at $5KN/m^2$

Fig.82: Failure of Sample at $10KN/m^2$

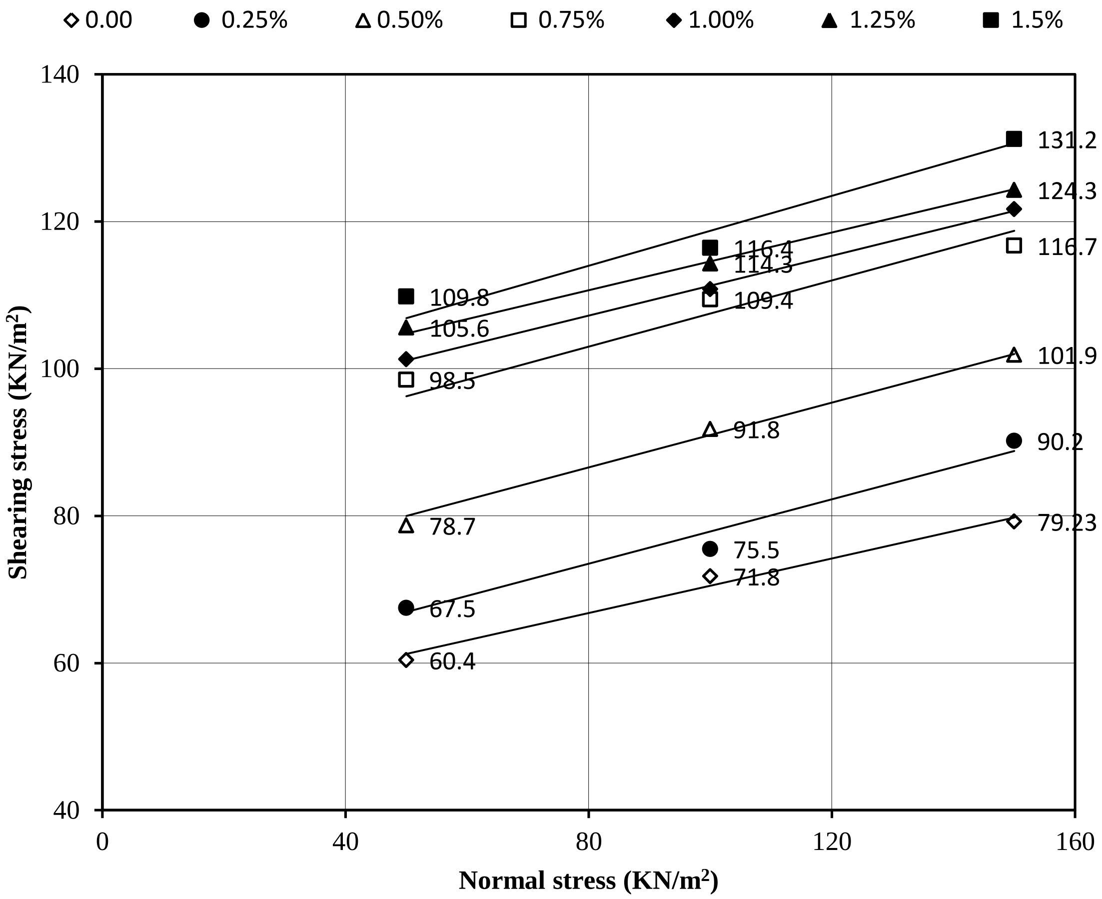

Fig.83: Variation of Shearing Stress with Normal Stress of soil reinforced with polypropylene Fibre in different Percentage

Table.23: Equation of Line, Slope & Intercept of Line are at different Percentage of Polypropylene Fibre

S.No.	**Percent of fibre**	**Equation of line**	$\emptyset = \tan^{-1} Slope$	**Intercept (cohesion)KN/m²**
1	0	Y=0.1853x+52	9.5	52
2	0.25	Y=0.2817x+56	12.3	56
3	0.50	Y=0.22x+69	12.4	69
4	0.75	Y=0.2249x+85	12.71	85
5	1.00	Y=0.2029x+91	11.4	91
6	1.25	Y=0.1959x+95	11.1	95
7	1.50	Y=0.2374x+95	13.4	95

According to fig.83 and table .23, tells us about the cohesion and angle of internal friction of the soil. Slope give the angle of internal friction and intercept give the cohesion of the soil. For 0%, 0.25%, 0.50%, 0.75%, 1.0%, 1.25% and 1.5% the value of cohesion is 52KN/m^2, 56KN/m^2, 69KN/m^2, 85KN/m^2, 91KN/m^2, 95KN/m^2 and 95KN/m^2 and angle of internal friction in degree 9.5, 12.3, 12.4, 12.71, 11.4, 11.1 and 13.4.

According to fig.84, it was find that for fibre content 0% to 0.25% and 1% to 1.5%, the cohesion value of the soil increases very less but for 1.25% and 1.5% it will be const. and further for fibre content 0.5% to 1% it will increases sharply.

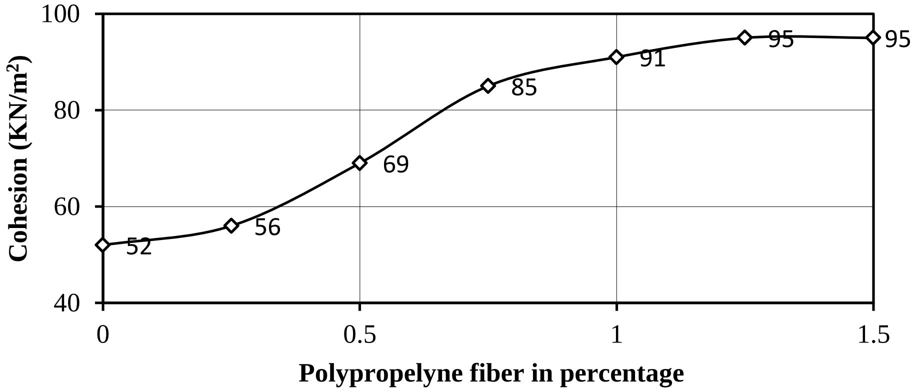

Fig.84: Variation of Cohesion with Polypropylene Fibre in different Percentage

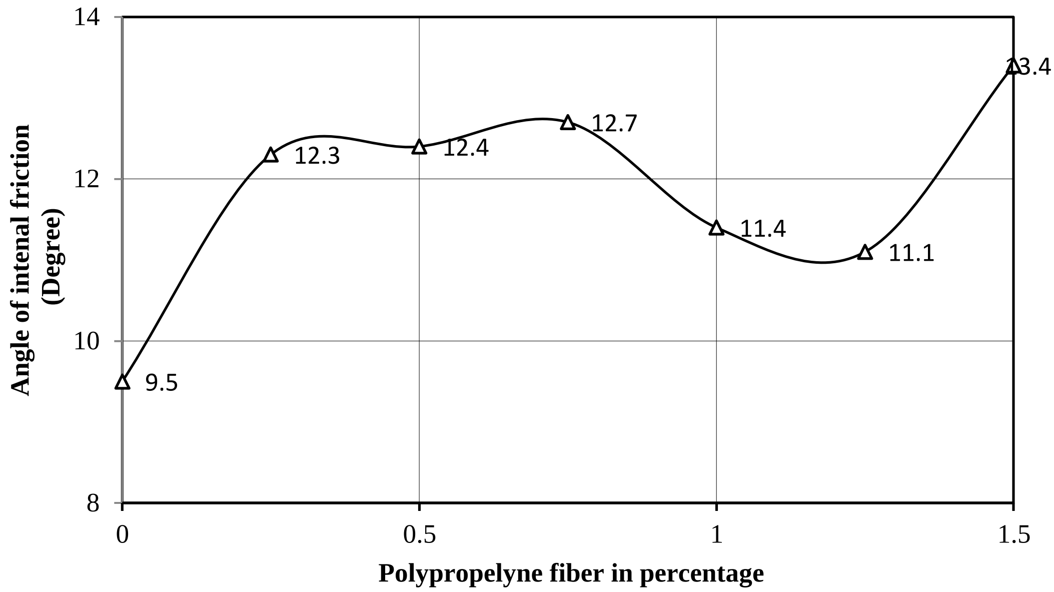

Fig.85 Variation of Angle of Internal friction with Polypropylene Fibre in different Percentage

From the fig.85, it was observed that for 0% to 0.25% and 1.25% to 1.5% the angle of internal friction increases sharply. For 0.25% to 0.75% it will increase very less and for 0.75% to 1% it will decrease sharply.

CHAPTER-5

COMPARISON OF RESULT

5.1 Compaction test:

1.0 According to fig 86 it was found that the increases in Optimum moisture content of soil is more in case of polypropylene fibre as compared to Jute fibre.

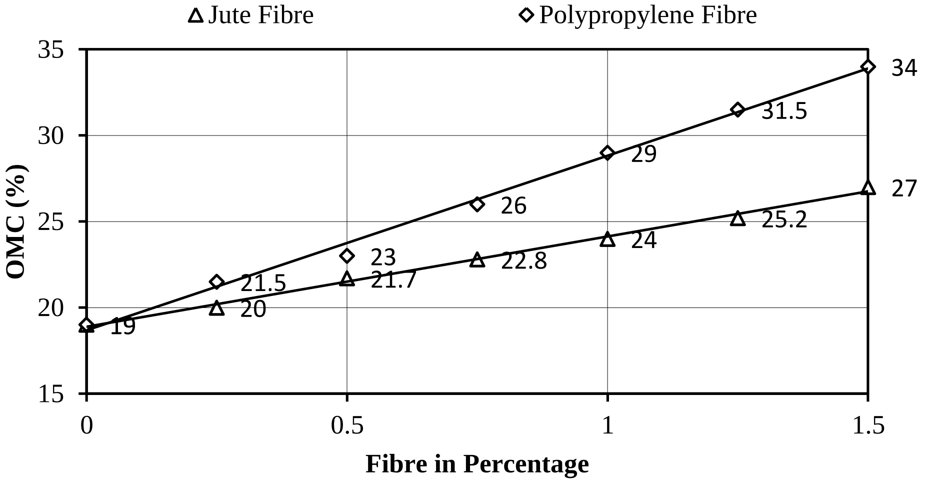

Fig.86: Variation of OMC with Fibres in different Percentage

2.0 According to fig 87 it was found that the decreases of maximum dry density in soil are more in case of polypropylene fibre as compared to Jute fibre.

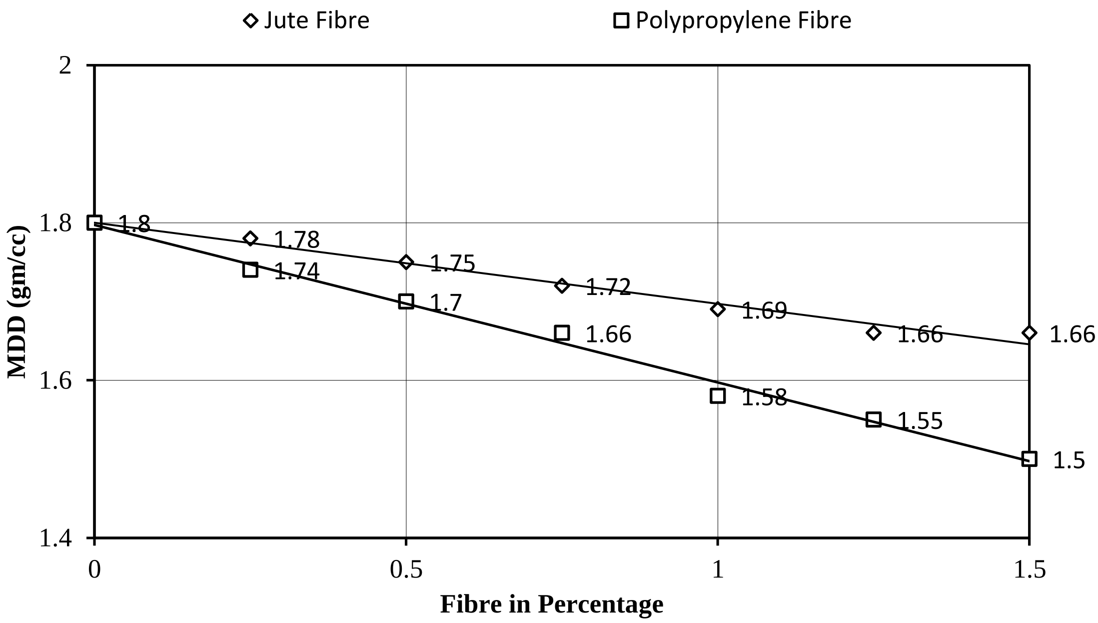

Fig.87: Variation of MDD with Fibres in different Percentage

5.2 Unconfined compressive strength

1.0 According to fig 88, it was observed that the increases in I day UCS of soil is more in case of polypropylene fibre as compared to Jute fibre.

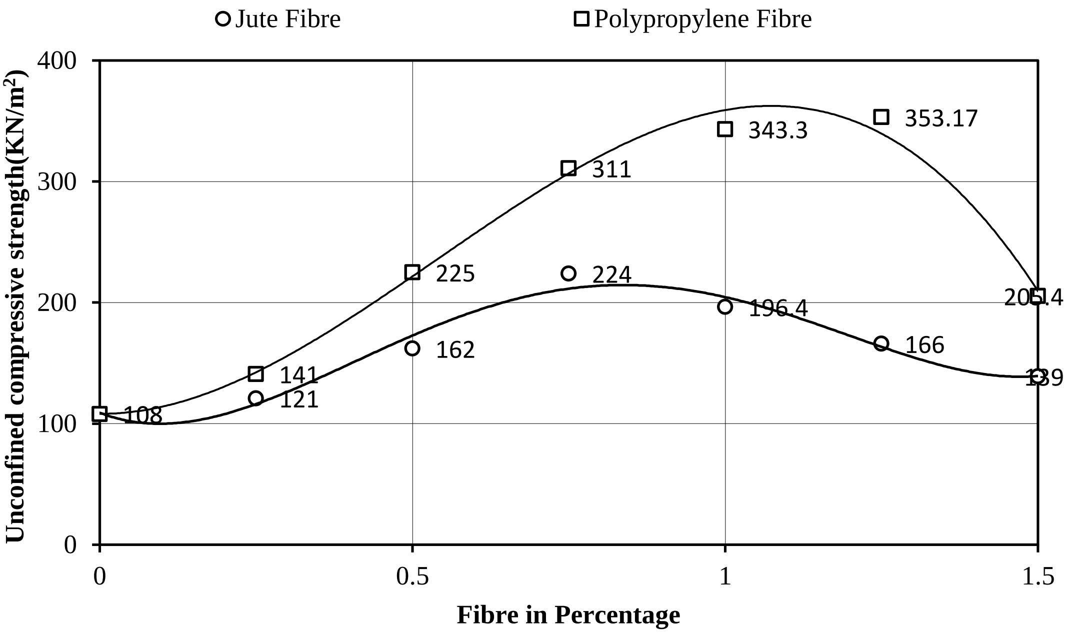

Fig.88: Variation of Unconfined Compressive Strength with Fibres in different Percentage at 1 Day curing period

2.0 According to fig 89, it was found that the increases in 7 days UCS of soil is more in case of polypropylene fibre as compared to Jute fibre.

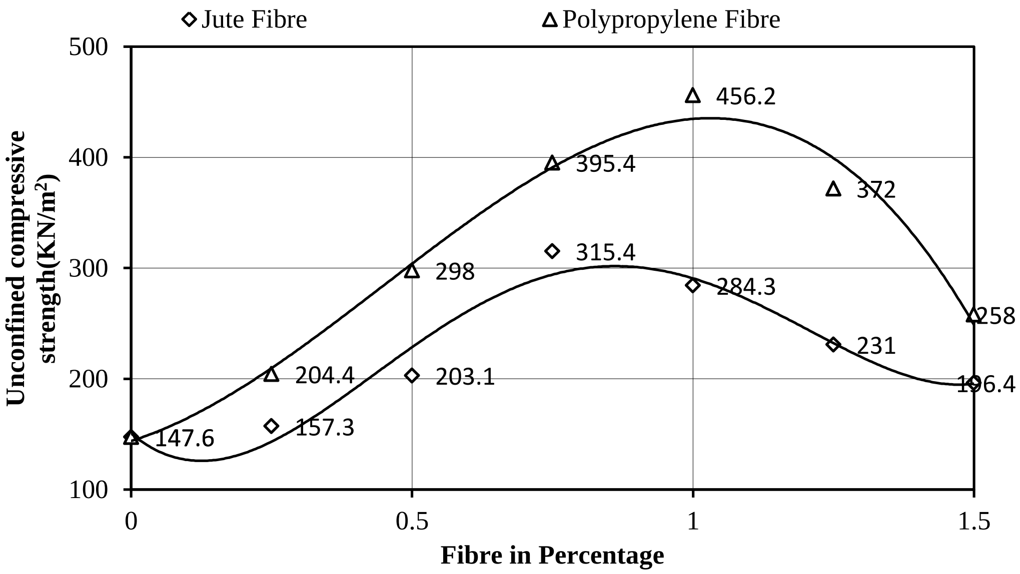

Fig.89: Variation of Unconfined Compressive Strength with Fibres in different Percentage at 7 Days curing period

3.0 According to fig 90, it was found that the increase in 14 day UCS of soil is more in case of polypropylene fibre as compared to Jute fibre.

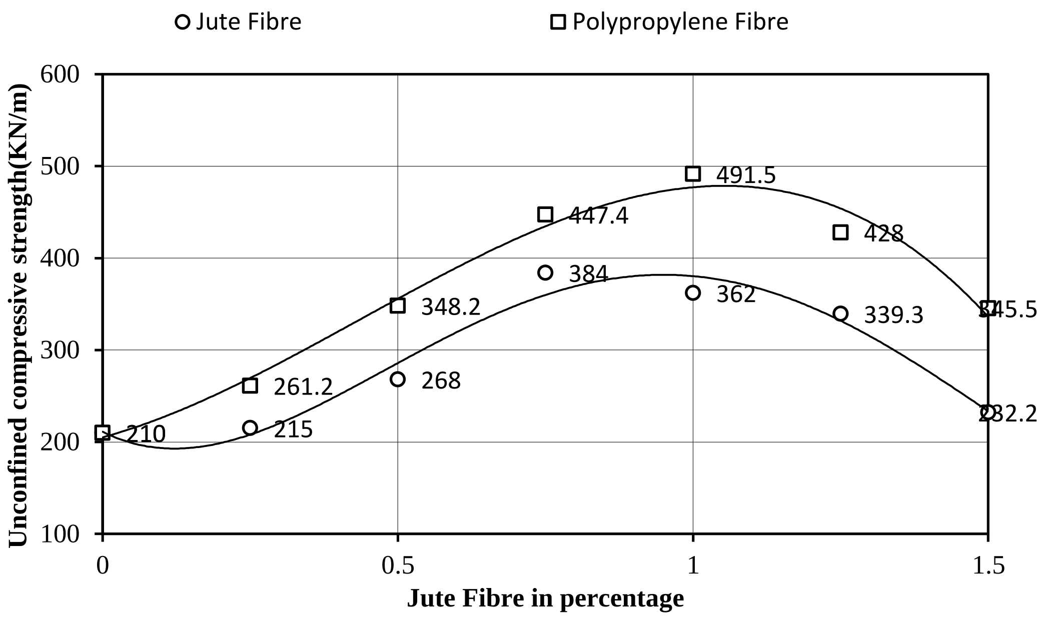

Fig.90: Variation of Unconfined Compressive Strength with Fibres in different Percentage at 14 Days curing period

5.3 California bearing ratio test:

According to fig 91, it was found that the increases in CBR value of soil are more in case of polypropylene fibre as compared to Jute fibre.

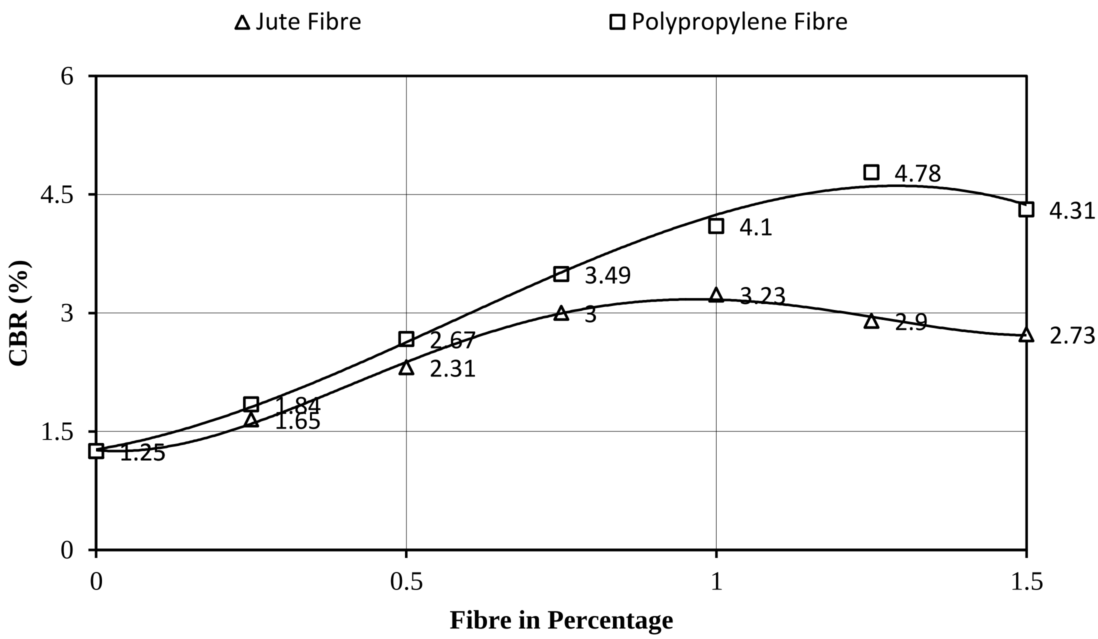

Fig.91: Variation of CBR with Fibres in different Percentage

5.4 Free swell Index test

According to fig 92, it was found that the increases in free swell index value of soil is more in case of polypropylene fibre as compared to Jute Jute fibre.

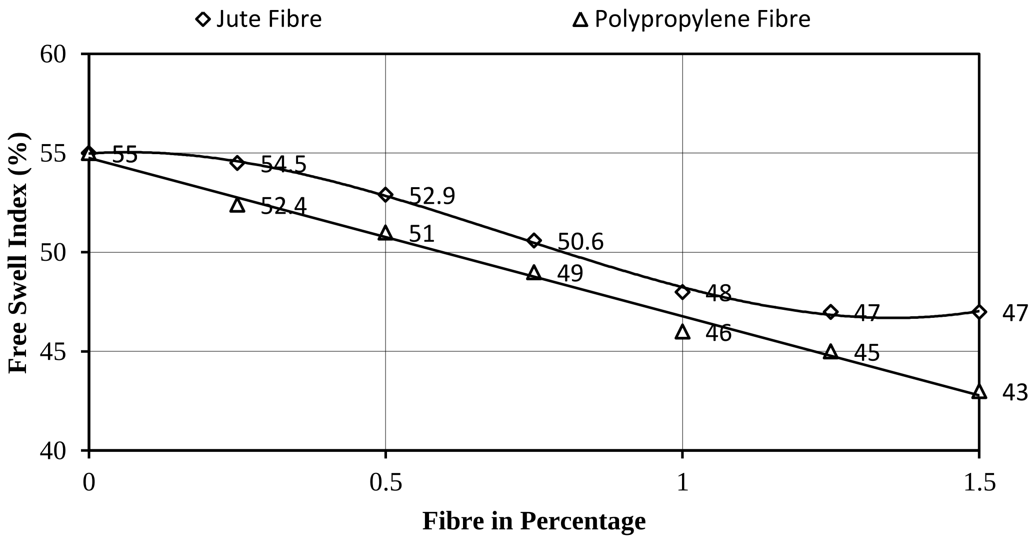

Fig.92: Variation of Free Swell Index with Fibres in different Percentage

5.5 Tensile strength test

1.0 According to fig 93, it was found that the increase in 7 day Tensile strength of soil is more in case of polypropylene fibre as compared to Jute fibre.

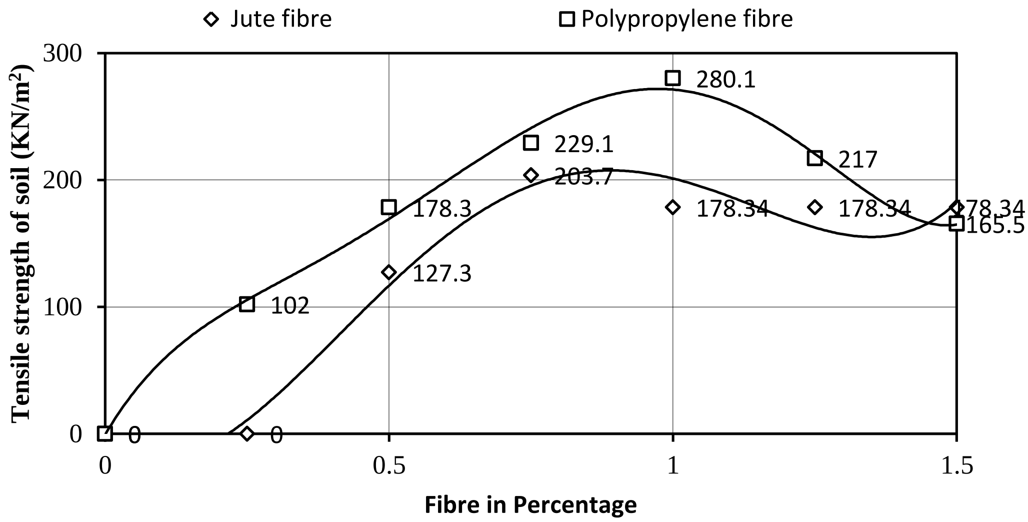

Fig.93: Variation of Tensile Strength with Fibres in different Percentage at 7 Days curing period

2.0 According to fig 94, it was found that the increase in 14 day Tensile strength of soil is more in case of polypropylene fibre as compared to Jute fibre.

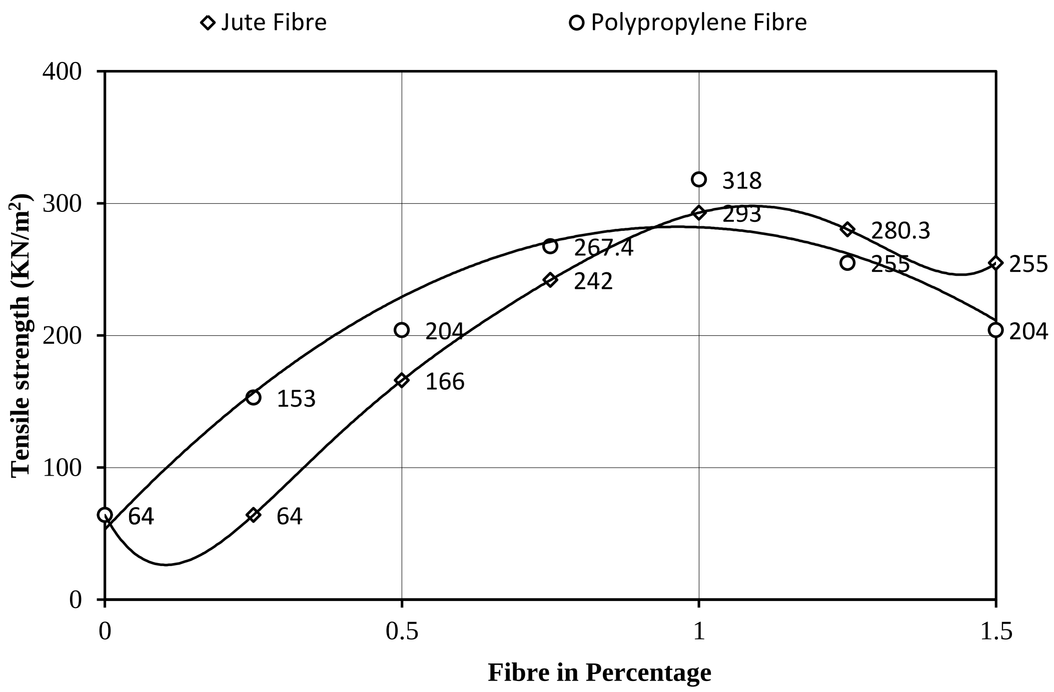

Fig.94: Variation of Tensile Strength with Fibres in different Percentage at 14Days curing period

5.6 Direct shear test:

1.0 0 According to fig 95, it was found that the increases in cohesion of soil is more in case of polypropylene fibre as compared to Jute fibre.

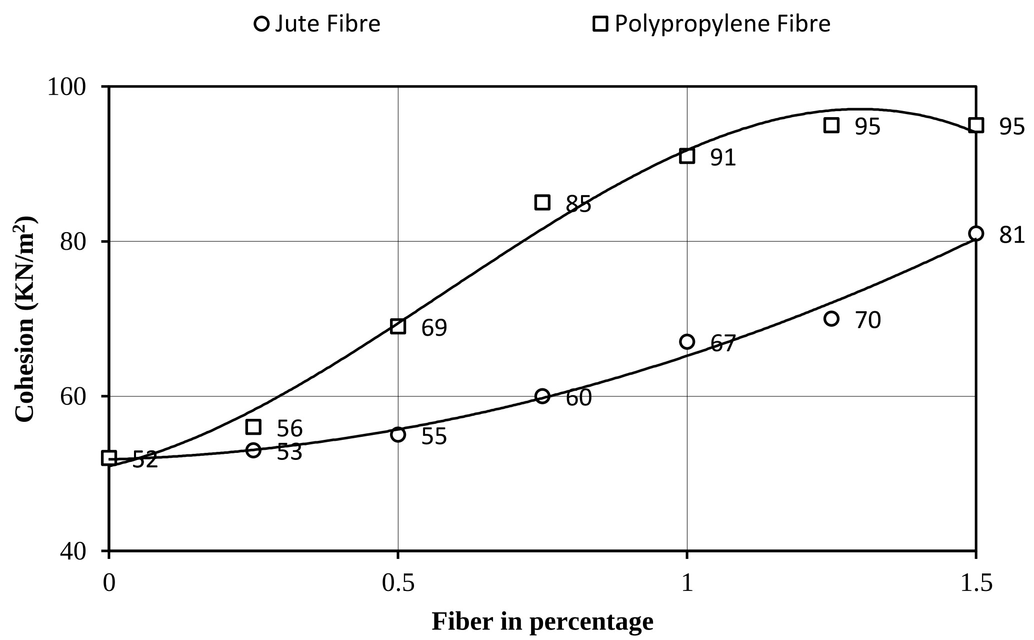

Fig 95: Variation of Cohesion with Fibres in different Percentage

2.0 According to fig. 96 it was found that for both fibre the angle of internal friction increases or decreases at different fibre content.

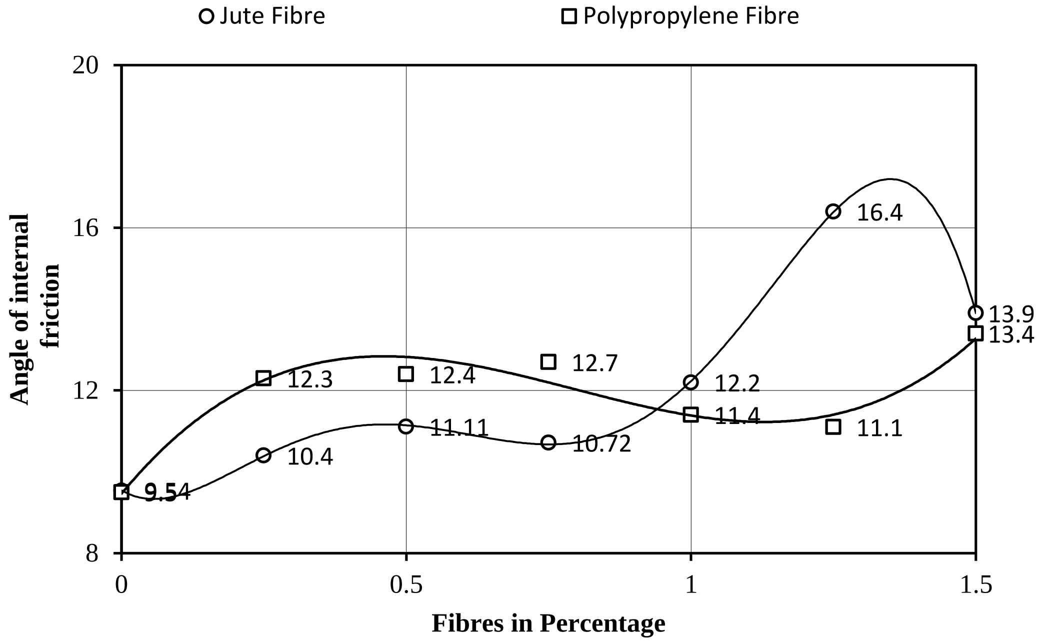

Fig.96: Variation of Angle of Internal Friction with Fibres in different Percentage

CHAPTER-6

CONCLUSION

6.1 CONCLUSION

1. Acc to compaction test result it can be shown that the OMC increases with the percentage polypropylene fibre is much more as compared to that of jute fibre, this is due to the taking of more water to acchive the OMC is higher in case of polypropylene fibre. Further the compaction test result shows that MDD of soil with polypropylene fibre is less than that of jute fibre. This is due to the density of jute fibre which is much more than that of polypropylene fibre. So Jute fibre achieves MDD soon.

2. Unconfined compression test result indicates that in polypropylene fibre the UCS value increasesd by 134% from 0 To 1% and after it starts decreasing, while in case of Jute fibre the UCS value increased by 72% from 0 to1% and after it starts decreasing.So it shows that the optimum value in both cases is 1% but the UCS value at 1% in polypropylene fibre comes to the more than that of Jute fibre.

3. California ratio test result indicates that in polypropylene fibre the CBR value increased by 282.4% from 0 to 1.25% and after it starts decreasing, while in case of Jute fibre the the CBR value increased by 158% from 0 to 1% and after it starts decreasing.So it shows that the optimum value in polypropylene fibre is 1.25%and in case of jute fibre it will be 1.00%

4. Free swell index test indicates that in case of polypropylene fibre the Degree of expansiveness is decreased by 21.8% from 0 to 1.5%, while in case of Jute fibre this value is decreased by 14.5% from 0 to 1.25% and after then it becomes constant for 1.5% of fibre content.

5. Tensile strength test result indicates that in case of polypropylene fibre the tensile strength of soil is increased by 396% from 0 to 1% and after that it will starts decreasing, while in case of Jute fibre this value increased by 357.8% from 0 to1% and after it will starts decrasing.So it shows that the optimum value in both cases is

1%, but the tensile strength of polypropylene fibre is more than that of Jute fibre at optimum content.

6. The shearing strength of soil reinforced with polypropylene fibre is more than that of Jute fibre .The value of cohesion for soil reinforced with polypropylene fibre is increased by 82.6% from 0 to 1.25% and further it will make const value while in case of Jute fibre this value increased by 55.7% from 0 to 1.5%.The angle of internal friction increases for both cases.

Acc to the above points it is concluded that polypropylene fibre enhance the property of soil more as compared to jute fibre. It will give better stability to the soil. So polypropylene fibre is good for stabilizing agent as compared to Jute fibre

6.2 SCOPE FOR FUTURE STUDIES

1. **Aspect ratio:**

   We can use the fibre of different length and different diameter at different percentage with soil, because length and diameter play an important role for the stability of soil.

2. **Liquefaction:**

   We can also study the liquefaction of fibre reinforced soil at different percentage.

3. **Consolidation:**

   We can also study the effect of settlement and compressibility of fibre reinforced soil.

4. **Bearing capacity:**

   We can study the bearing capacity of soil by CBR test in soaked condition.

5. **Permeability:**

   We can study the permeability of fibre reinforced soil