CHAPTER 1

INTRODUCTION

1.1 INDUSTRIAL WASTE:

Solid and semi-solid constituents that are unwanted by the community are known as solid waste. Improper disposal of these wastes causes negative impact on the ecology which may lead to cause possible outbreak of diseases, epidemics, ecological misbalance or pollution. Solid wastes are divided in to three group's namely Industrial waste, Agricultural waste, and Municipal waste.

These industrial waste may be used as source of substitute material for stabilization or dumping purpose which are cheaply available, by using these wastes as construction material will provide solution for problems of pollution and disposal of these wastes. Some of the waste material which are being used for road construction now a days are presented in table below with their relative advantages and disadvantages.

WASTE PRODUCT	SOURCE	POSSIBLE USE
Fly ash	Thermal power plant	Bulk fill, filler in bituminous mix, artificial aggregates
Blast furnance slag	Steel industry	Base/ Sub-base material, Binder in soil stabilization (ground slag)
Cement klin dust	Cement industry	Stabilization of base, binder in bituminous mix
Used engine oil	Automobile industry	Air entraining of concrete
Marble dust	Marble industry	Filler in bituminous mix
Waste tyre	Automobile industry	Rubber modified bitumen, aggregate

Table 1.1 : Industrial waste product usage in road construction

MATERIAL	ADVANTAGES	DISADVANTAGES
Fly ash	Lightweight, used as binder in stabilized base/ sub-base due to pozzolanic properties	Lack of homogeneity, presence of sulphates, slow strength development
Blast furnace	More strength, can be used as aggregates granular base	Ground water pollution due to leachate formation, used as unbound aggregates
Cement kiln dust	Hardens when exposed to moisture, can be used in soil stabilization	Corrosion of metals (used in concrete roads) in contact because of significant alkali percentage
Used engine oil	Good air entertainer, can be used in concrete work	Requires well organized used oil collection system
Rubber tires	Enhances fatigue life	Requires special techniques for fine grinding and mixing with bitumen, sometimes segregation occurs
demolition waste	More strength, can be used as aggregates granular base	Ground water pollution due to leachate formation, used as unbound aggregates

Table 1.2: Advantages and disadvantages of using specific industrial wastes

1.2 KOTA STONE :

Kota stone dust which is our material of study is an industrial waste which comes from Kota stone mines and finishing industries as a byproduct. Kota Stone is a fine-grained variety of limestone, quarried at Kota district, Rajasthan, India. Many hundreds of mines are located in or near the town of Ramganj mandi and Kota district. Kota stone is found in various shades such as rich greenish blue , Brown ,Black ,pink and gray. This stone is used for passageways, balconies, flooring, wall fixing and lining. As it has low absorbing property so it is also used for chemical industries for flooring also. It has various properties as though, non-water absorbing, non-slip and non-porous so it is very famous among people. In our study we use Kota stone dust as a stabilizing material for black cotton soil and we compare our result with fly ash and Kota stone stabilized black cotton soil.

Fig 1.1 Kota stone cutting machine

1.2.1 GENERATION OF WASTE:

Without proper understanding of quarrying technology comes in a result of large amount of waste generation and small level of mineral recovery from mines. Improper mining technology generate solid as well as slurry waste, similarly both form of wastes are generated during cutting and sizing process. Slurry waste generated while slab of Kota stone is rubbed mechanically with other stone layer with water as cooling agent and flushing out waste material. Improper disposal of this slurry may cause serious problem to agricultural field and also to nearby water body causing blockage.

Fig 1.2 Huge Waste Dumps Kota Stone Mines

1.3 FLY ASH:

Fly ash produces during combustion of coal in industries to get heat; mainly it is generated from thermal power plants. Fly ash is collected from electrostatic precipitator when flue gases reach to top of chimney. Bottom ash is the ash which cannot fly with flue gas while ash which goes with flue gas is known as flue ash or fly ash, combined fly ash and bottom ash is termed as coal ash. Elemental composition of fly ash depends upon source and type of coal used but all fly ash contain silicon dioxide and calcium oxide.In past it was released to atmosphere But to control pollution it collected by some means and disposed carefully, now these days it is used as stabilizing agent due to virtue of pozzolanic reactions.

According to ASTM C618 , fly ash is classified into two classes based on Ca, Al, Si and Fe content as class c fly ash and class F fly ash. Class C fly ash have Cao more than 20% so it has some cementatious property when it is mix with water due to pozzolanic reaction it gain strength with time.

1.4 BLACK COTTON SOIL:

Black cotton soil is an expansive soil which have excessive shrink and swell tendency with change of water content, as water is added , it swell and if water is removed by some means it shrinks. Such tendency of soil is due to presence of montmorillonite mineral in soil. In this project we will do stabilization of black cotton soil with Kota stone dust and fly ash. Due to high swell pressure this soil causes damage to structure which in turn loss to nation's economy. Black cotton soil have large specific surface area, particles below 2 micron , high cation exchange capacity and high liquid limit and plasticity index value.

In our country about 1/6 area, mostly the Deccan Trap plateau, between 73°80'East longitude and 15° to 24° north, latitude is covered by black cotton soil; that means very large area is affected by this type of soil.The regions as Mumbai, Madras , Gwalioar, bundelkhand Khandwa, Indore, Nagpur are covered by this soil.

CHAPTER 2

LITRATURE REVIEW

Numerous research papers were studied for literature review, very less data was available on Kota stone dust though test were performed on Kota stone dust ,fly ash and black cotton soil. Kota stone dust have free lime so it behaves like marble dust.

Based on the test result achieved in the study Nadgouda, K.A. and Hegde, R.A. (2010) concluded that when we add lime to black cotton soil it diminishes it's swelling characteristics when soil come in contact with water. According to them the optimum percentage of lime for improving the property is in the range of 3% to 4%.

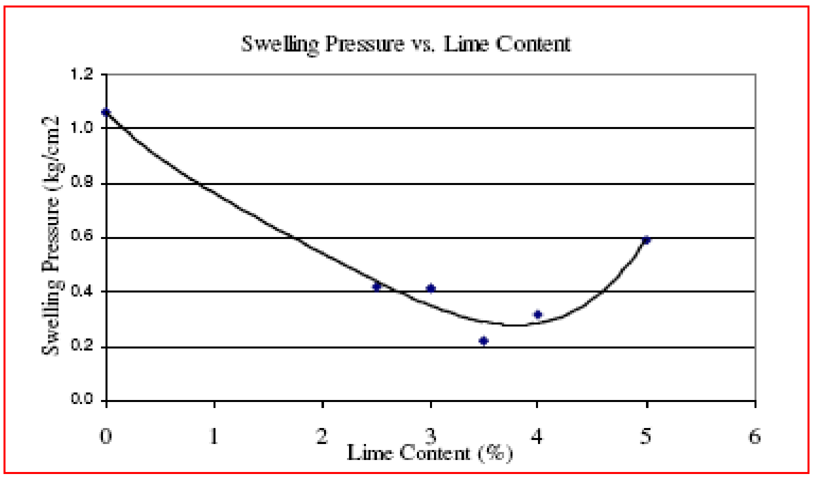

Fig2.1 Lime effect on swelling of BCS

According to work done by A.J.Krishnaiah, H.N.Ramesh and S.Shilpa shet (2013**)** on BCS which was stablised with Cao & mine tailing mixture following conclusion were made on index property

1. Liquid limit of mixture of BCS and mine tailing increases with curing period as we add lime due to thickness of diffused double layer increases while initially liquid limit decreases compare to original BCS. The mixture of BCS and Mine tailing increases liquid limit for initial curing period and then reduces afterthat upto 60 % addition of mine tailing if more mine tailing is added to BCS than phenomena reverse.

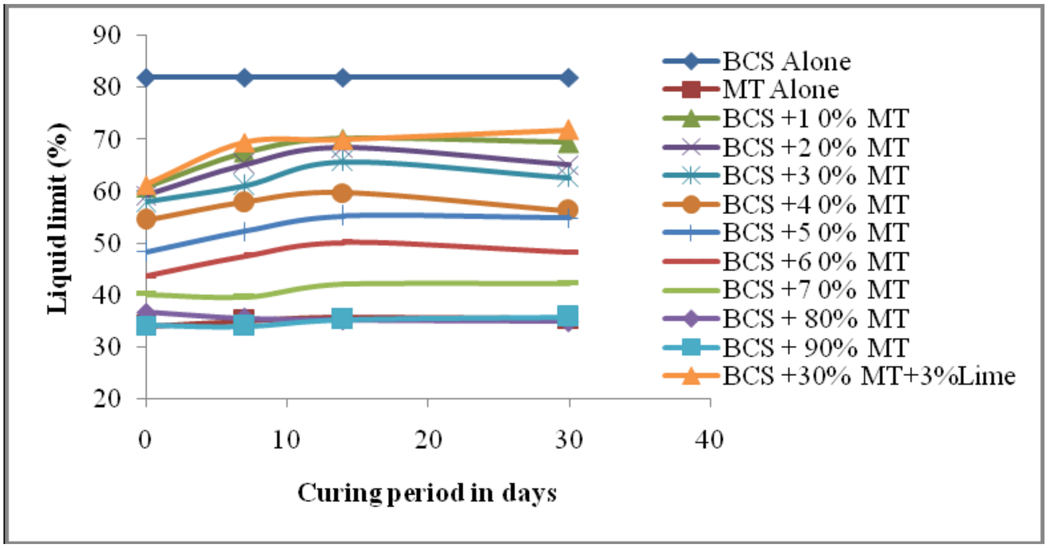

Fig 2.2 Liquid limit vs curing period

2. Plastic limit of mixture of BCS and mine tailing increases with curing period as we add lime due to thickness of diffused double layer increases while initially Plastic limit decreases compare to original BCS. The mixture of BCS and Mine tailing have almost constant value of plastic limit for curing period.

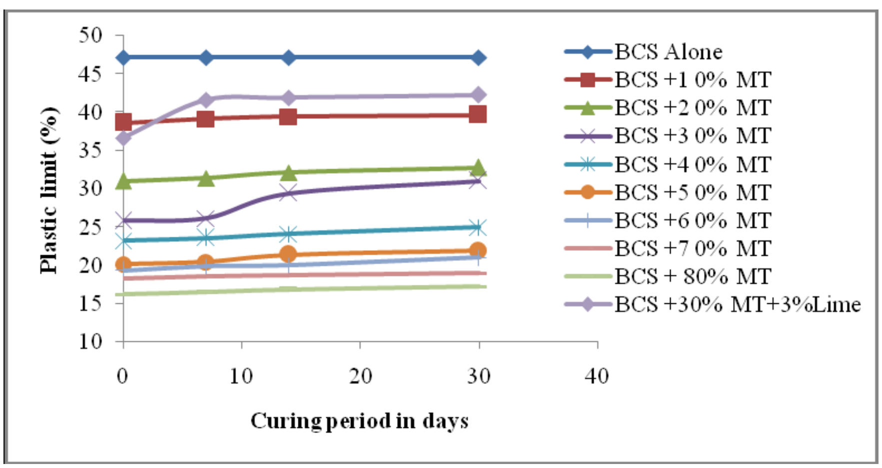

Fig 2.3 Plastic limit vs curing period

3. Plasticity index of BCS mixed with mine tailing mixture reduces with increase in mine tailing content which changes soil from MH to CI, reduction in plasticity index is good from workability point of view.

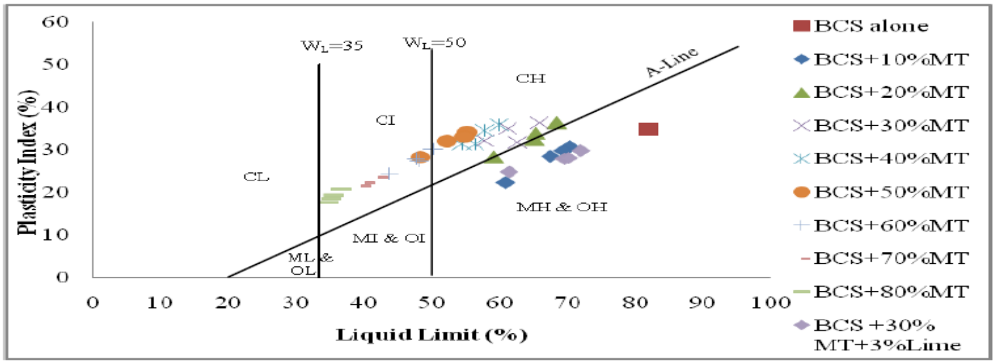

Fig 2.4 Soil classification chart

According to work done by K.V. Madurwar1, P.P. Dahale2, A.N.Burile on expansive soil with RBI Grade 81 and sodium silicate to stabilize and overcome the ill effect of expansive soil when it come with contact with water and gave conclusion as, On addition of admixture(RBI Grade 81 or sodium silicate) plasticity index reduces because plastic limit increases and liquid limit decreases. Similarly admixture increases the value of UCS as its content is increased which prove that they are good in stabilizing. As we know that water is capable to make sodium silicate soluble in water so we cannot use alone this as stabilizing agent.

AS work done by U.M. Graham, T.L. Robl, R.F. Rathbone on adsorptive property of fly ash carbon they conclude that during incomplete combustion of coal particles of charcoal are released and we can get activated carbon by steam action or by chemical action which has an adsorption activity towards phenolic compounds, so we can get with help of experiment maximum capacity and optimum dose can be found by experiments.

As per the work done by Bidula Bose on "geo-engineering properties of expansive soil stabilized with fly ash" The adding of fly ash reduces the plasticity index of Black cotton soil. The consistency limits decreased extremely and shrinkage limit enlarged with the addition of fly ash. The FSI value and swelling pressure is found to decrease with growth in fly ash content.

As work done by A. Sridhara and K. Prakash (2000) on "classification of expansive soil" based on various criteria such as liquid limit criteria plastic limit criteria and free swell index criteria.

Degree of expansion	Liquid limit(%)	
	Chen	IS1498
Low	<30	20-35
Medium	30-40	35-50
High	40-60	50-70
Very high	>60	70-90

Table 2.1Soil expansivity prediction by liquid limit

Degree of expansion	Plasticity index(%)		
	Holtz and Gibbs	Chen	IS1498
Low	<20	0-15	<12
Medium	12-34	10-35	12-23
High	23-45	20-55	23-32
Very high	>32	>35	>32

Table 2.2 Soil expansivity prediction by Plasticity index

Oedometer Percentage expansion	Free Swell Ratio	Clay type	Soil expansivity
<1	<1.0	Non swelling	Negligible
1-5	1.5-1.5	Mixture of swelling and non swelling	Low
5-15	1.5-2.0	Swelling	Moderate
15-25	2.0-4.0	Swelling	High
>25	>4.0	Swelling	Very high

Table 2.3 Classification based on free swell ratio

According to work done by Bairwa Ramlakhan , Saxena Anil Kumar, Arora T.R. on" effect engineering property of Black cotton soil with lime and fly ash" conclude that addition of fly ash decreases liquid limit and plastic limit while addition of lime to mixture increases liquid limit and plastic limit. Optimum moisture content increases and maximum dry density decreases with increasing amount of fly ash, similarly OMC increases and MDD decreases with addition of lime also.

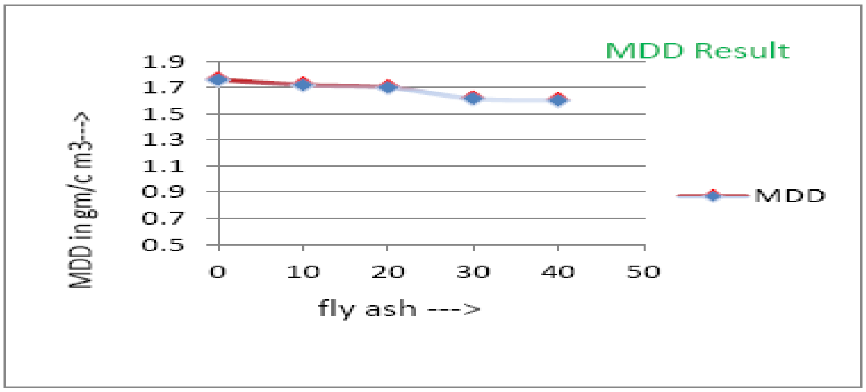

Fig 2.5 MDD vs Fly ash

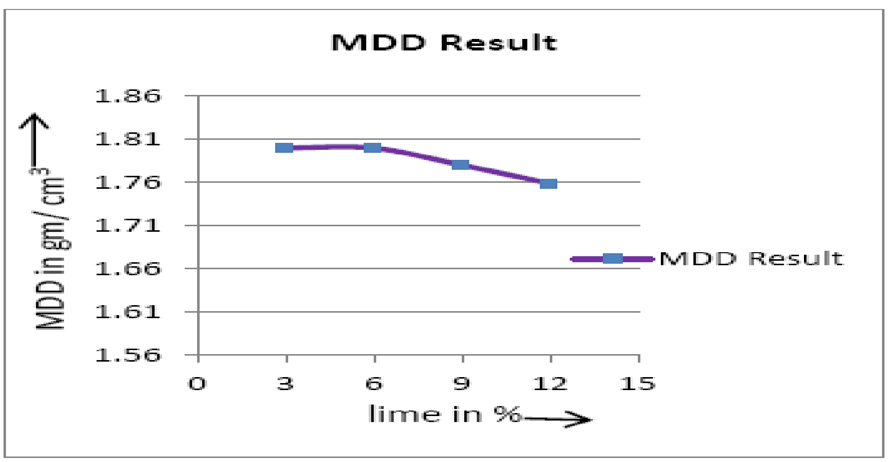

Fig 2.6 MDD vs lime

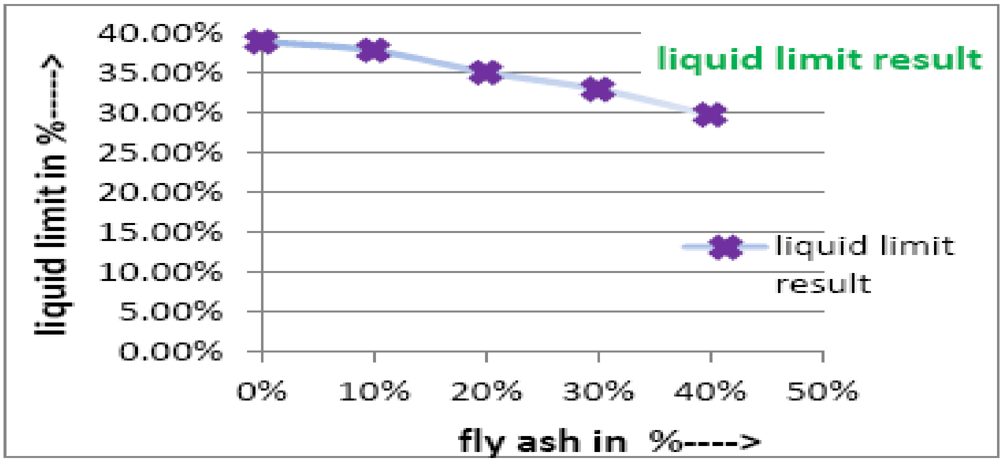

Fig 2.7 Liquid limit vs fly ash

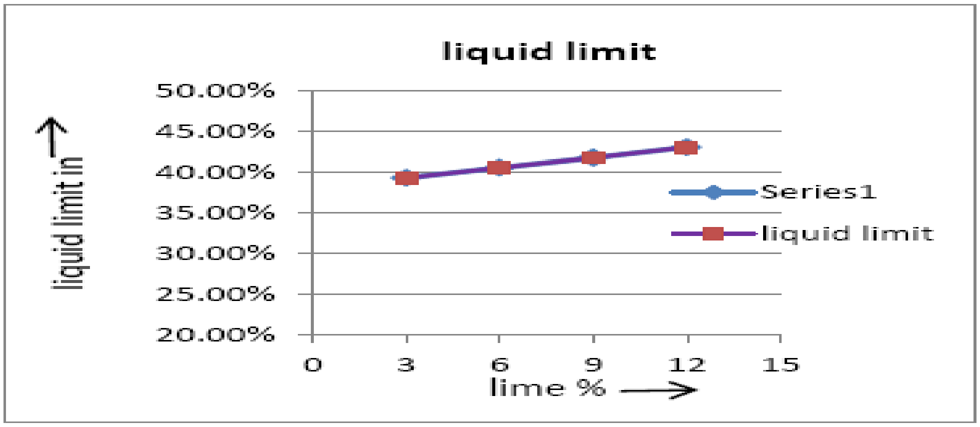

Fig 2.8 Liquid limit vs lime

As per the work done by Gyanen, Takhelmayum, Savitha.A.L, Krishna Gudi on "laboratory study on soil stabilization using fly ash mixtures " In analysis they use percentage mix of coarse and fine fly ash in the range of 5 to 30% with black cotton soil. The MDD was 1.35 g/cc for 95% soil and 5% fly ash mixture and minimum MDD was about 0.6g/cc for 70% soil and 30% fly ash mixture. This difference of density is primarily due to modification of degree of soil mixtures

Work done byV K Sowmya, P Dilsha on “effect of rice husk ash on strength and durability of lime stabilized black cotton soil” concluded that long-term outcome in investigation with rice husk ash to BCS soil which was stabilized by lime and wetting –drying cycles give their result as

1. Increase in rice husk ash content with lime stabilized soil plastic as well as liquid limit gradually increases.

2. With increase in RHA content MDD reduces and OMC rises.

3. The UCS goes up with increase in RHA content up to a limit and after this UCS value goes down as we increase the amount of RHA. On increasing curing period the value of UCS also increases and according to investigation the optimum dose was 10% of RHA.

4. wetting-drying cycles results in increase in UCS up to some cycles and then value of UCS start decreasing as we increase wetting-drying cycles.

5. Only of 15% and 10% RHA mixed soil can withstand for 12 cycles of wetting-drying. The reason for this is that during curing period pozzolanic reaction takes place with lime and rice husk ash.

6. Based on the durability criteria the optimum dose is 10% rice husk ash with 9% lime to the black cotton soil.

CHAPTER 3

METHODS AND MATERIAL

3.1 KOTA STONE DUST:

For our study purpose we get KSD from stone finishing industries near Kota district in Rajasthan. Kota stone dust is a lime stone by nature and it is found in various colors such as red , gray ,blue etc. It is a waste byproduct from industry which may be harmful for society if disposed randomly. Our aim is that we will make some use of this waste so that it may become ecofriendly product.

3.2 FLY ASH:

We use fly ash as stabilizing admixture, In past it was released to atmosphere But to control pollution it collected by some means and disposed carefully, now these days it is used as stabilizing agent due to virtue of pozzolanic reactions. We get this material from Kota thermal power plant , near Kota city. According to ASTM C618 , fly ash is classified into two classes based on Ca, Al, Si and Fe content as class c fly ash and class F fly ash. Class C fly ash have Cao more than 20% so it has some cementatious property when it is mix with water due to pozzolanic reaction it gain strength with time.

3.3 BLACK COTTON SOIL:

In our project we will do stabilization of black cotton soil with Kota stone dust and fly ash. Due to high swell pressure this soil causes damage to structure which in turn loss to nation's economy.so we will make use of KSD for stabilizing BCS so that this waste material may get it's place as ecofriendly material.

3.4. PROPERTIES OF MATERIALS:

3.4.1. BLACK COTTON SOIL:

3.4.1.1. INDEX PROPERTY:

Specific Gravity:2.71

Liquid limit=53.50

Plastic limit=25.60

Plasticity Index=27.9

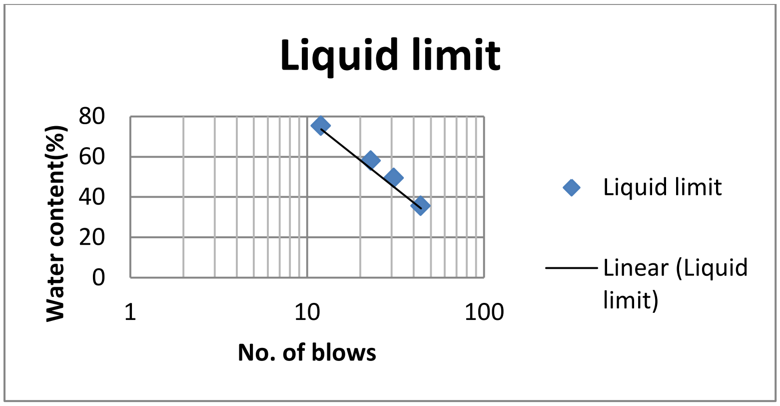

Fig 3.1 Liquid limit curve for black cotton soil

3.4.1.2. STANDARD PROCTOR TEST:

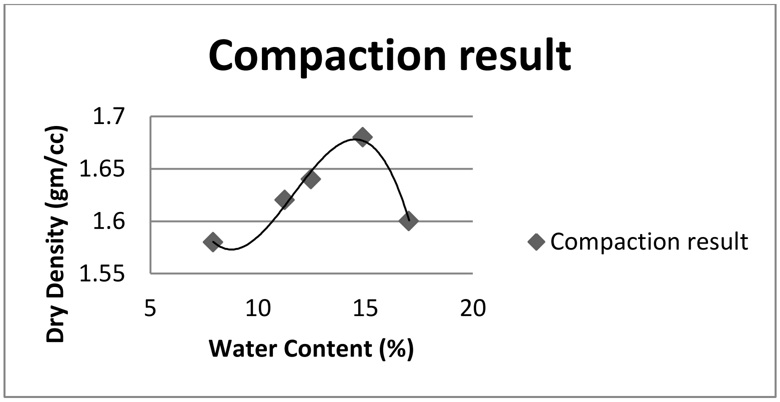

Fig 3.2 Curve for standard proctor test of BCS

OMC of BCS=14.50%

MDD of BCS=1.68g/cc

3.4.1.3. FREE SWELL INDEX :

Initial volume in water = 6.4

Initial volume in kerosene= 6.4

Final volume in water= 9.4

Final volume in kerosene= 6.4

Free Swell Index(%)=46.88

3.4.1.4. UCS RESULT:

UCS for 1 day=79.29 KPa

UCS for 7 day=118.94 KPa

UCS for 28 day=135.32 KPa

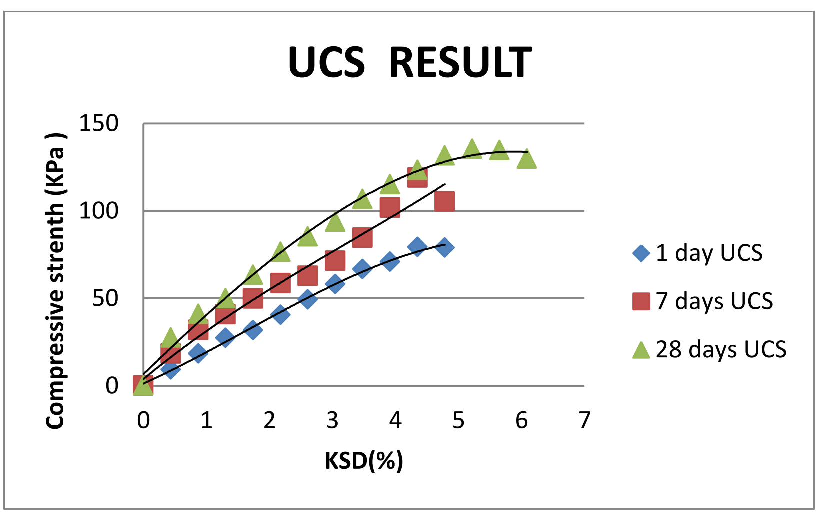

Fig 3.3 : Curve for UCS test of BCS

3.4.1.5. Scanning Electron Microscope (SEM) Test:

Element Line	Net Counts	Int. Cps/nA	Weight %	Weight % Error	Atom %	Atom % Error	Formula	Standard Name
O K	3327	---	59.89	+/- 1.51	74.00	+/- 1.87	O	
Al K	605	---	6.22	+/- 0.40	4.56	+/- 0.29	Al	
Si K	2464	---	26.99	+/- 1.00	19.00	+/- 0.70	Si	
Si L	0	---	---	---	---	---		
Fe K	107	---	6.90	+/- 1.42	2.44	+/- 0.50	Fe	
Fe L	758	---	---	---	---	---		
Total			100.00		100.00			

Fig 3.4 SEM result for BCS

3.4.2. KOTA STONE DUST:

Liquid limit=34.19

Plastic limit=27.3

Specific Gravity=2.59

OMC=23.1%

MDD=1.321gm/cc

Element Line	Net Counts	Int. Cps/nA	Weight %	Weight % Error	Atom %	Atom % Error	Formula	Standard Name
C K	223	0.000	4.09	+/- 0.26	7.31	+/- 0.46	C	
O K	1164	0.000	47.30	+/- 1.30	63.51	+/- 1.75	O	
Mg K	60	0.000	0.58	+/- 0.13	0.51	+/- 0.11	Mg	
Al K	208	0.000	1.74	+/- 0.15	1.39	+/- 0.12	Al	
Si K	1304	0.000	10.81	+/- 0.27	8.27	+/- 0.20	Si	
Si L	0	0.000	---	---	---	---		
Ca K	2452	0.000	35.48	+/- 1.03	19.01	+/- 0.55	Ca	
Ca L	0	0.000	---	---	---	---		
Total			100.00		100.00			

Fig 3.5 SEM result of Kota stone dust

3.4.3. FLY ASH:

Liquid limit=32%

Plastic limit=Non plastic

Specific Gravity=2.13

OMC=19%

MDD=1.35gm/cc

Element Line	Net Counts	Int. Cps/nA	Weight %	Weight % Error	Atom %	Atom % Error	Formula	Standard Name
O K	2199	---	54.06	+/- 1.35	67.03	+/- 1.68	O	
Al K	1493	---	18.20	+/- 0.96	13.38	+/- 0.71	Al	
Si K	1955	---	27.74	+/- 1.18	19.59	+/- 0.83	Si	
Si L	0	---	---	---	---	---		
Total			100.00		100.00			

Fig 3.6 SEM result for Fly ash

3.5.COURSE OF PLAN:

To find out the geotechnical use of Kota stone dust we did some test which are liquid limit test plastic limit standard proctor Unconfined Compressive Strength and free swell index test with black cotton soil stabilized with Kota stone dust and then we again repeat the same test and did stabilization of black cotton soil with varying percentage of Kota stone dust and fly ash and compare the result obtained.

We did mix fly ash at an increment of 5 % starting from 0 % to 15 % and at the same time we did mix Kota stone dust at an increment of 3 % starting from 0 % to 15 %. So we get following 20 soil mixes which are as 1. Soil with 0% FA with 0% Kota stone dust, 2. Soil with 0% FA with 3% Kota stone dust, 3 . Soil with 0% FA with 6% Kota stone dust, 4. Soil with 0% FA with 9% Kota stone dust, 5. Soil with 0% FA with 12% Kota stone dust, 6. Soil with 5% FA with 0% Kota stone dust, 7. Soil with 5% FA with 3% Kota stone dust, 8. Soil with 5% FA with 6% Kota stone dust, 9. Soil with5% FA with 9% Kota stone dust, 10. Soil with 5% FA with 12% Kota stone dust, 11. Soil with10% FA with 0% Kota stone dust , 12. Soil with 10% FA with 3% Kota stone dust , 13. Soil with 10% FA with 6% Kota stone dust 14. Soil with 10% FA with 9% Kota stone dust , 15. Soil with 10% FA with 12% Kota stone dust 16. Soil with

15% FA with 0% Kota stone dust , 17. Soil with 15% FA with 3% Kota stone dust , 18. Soil with 15% FA with 6% Kota stone dust ,19. Soil with 15% FA with 9% Kota stone dust and 20. Soil with 15% FA with 12% Kota stone dust.

3.6 TEST PROCEDURES:

3.6.1SCANNING ELECTRON MICROSCOPE (SEM):

A scanning electron microscope (SEM) is a type of electron microscope that images a sample by scanning it with a high-energy beam of electrons in araster scan pattern. The electrons interact with the atoms that make up the sample producing signals that contain information about the sample's surface topography, composition, and other properties such as electrical conductivity.

The types of signals produced by an SEM include secondary electrons, back-scattered electrons (BSE), characteristic X-rays, light (cathodoluminescence), specimen current and transmitted electrons. Secondary electron detectors are common in all SEMs, but it is rare that a single machine would have detectors for all possible signals.

The signals result from interactions of the electron beam with atoms at or near the surface of the sample. In the most common or standard detection mode, secondary electron imaging or SEI, the SEM can produce very high-resolution images of a sample surface, revealing details less than 1 nm in size. Due to the very narrow electron beam, SEM micrographs have a large depth of field yielding a characteristic three-dimensional appearance useful for understanding the surface structure of a sample.

This is exemplified by the micrograph of pollen shown to the right. A wide range of magnifications is possible, from about 10 times (about equivalent to that of a powerful hand-lens) to more than 500,000 times, about 250 times the magnification limit of the best light microscopes. Back-scattered electrons (BSE) are beam electrons that are reflected from the sample by elastic scattering. BSE are often used in analytical SEM along with the spectra made from the characteristic X-rays. Because the intensity of the BSE signal is strongly related to the atomic number (Z) of the specimen, BSE images can provide information about the distribution of different elements in the sample. For the same reason, BSE imaging can image colloidal gold immuno-labels of 5 or 10 nm diameter, which would otherwise be difficult or impossible to detect in secondary electron images in biological specimens. Characteristic X-rays are emitted when the electron beam removes an inner shell electron from the sample, causing a higher energy electron to fill the shell and release energy. These characteristic X-rays are used to identify the composition and measure the abundance of elements in the sample.

Figure.3.7 Scanning electron microscope

3.6.2. LIQUID AND PLASTIC LIMIT TESTS:

Object: - To determine liquid limit and plstic limit.

Apparatus: -

- Casagrande liquid limit device
- ASTM and BS grooving tool
- Glass plate 20 x 15 cm
- 425 micron I.S. Sieve
- 3 mm diameter rod
- Balance (0.01gm sensitivity)
- Drying oven
- Distilled water
- Measuring cylinder

Precautions:

1. Use distilled water in order to minimize the possibility of iron exchange between the soil and any impurities in the water.
2. Soil used for liquid and plastic limit determinations should not be oven dried prior to testing.
3. In liquid limit test, the groove should be closed by a flow of the soil and not by slippage between the soil and the cup.
4. After mixing distilled water to the soil sample, sufficient time should be given to permeate the water throughout the soil mass.
5. Wet soil taken in the container for moisture content determinations should not be left in the air even for some time, the containers with soil samples should either be placed in desiccators or immediately be weighed.
6. For each test, cup and grooving tool, should be clean.

3.6.3. COMPACTION TEST (STANDARD PROCTOR):

Object:-To determine the optimum moisture content and maximum dry density of a soil by proctor test

Apparatus:-

1. Cylinder mould
   (Capacity 1000 c.c., internal dia.100 mm, effective ht. 127.3 mm)
2. Rammer for light compaction (face dia. 50 mm., mass of 2.6 kg, free drop 310 mm)
3. Rammer for heavy compaction (face dia50 mm, mass4.89 kg, free drop 450mm
4. Mould accessories (detachable base plate removal collar)
5. I.S. Sieves (20 mm,4.75 mm)
6. Balance (Capacity 200 gm sensitivity 0.01 gm)
7. Drying oven (temperature 105°C to 11°C)
8. Desiccators
9. Graduated jars
10. Straight edge
11. Spatula
12. Scoop

Figure.3.8 Proctor test

Precautions:-

1. Adequate period is allowed for mixing the water with soil before compaction.

2. The blows should be uniformly distributed over the surface of each layer.

3. Each layer of compacted soil is scored with spatula before placing the soil for the succeeding layer.

4. The amount of soil used should be just sufficient to fill the mould i.e.” at the end of compacting the last layer the surface of the soil should be slightly (5 mm) above the top rim of the mould.

5. Mould should be placed on a solid foundation during compaction.

3.6.4. Differential Free Swell Test:

Two sample of dried soil weighing 10g each , passing through 425 micron sieve are taken . one is put in a 50cc graduated glass cylinder containing kerosene. Other sample is put is a similar cylinder containing distilled water. Both the samples are left undisturbed for 24 hours and then there volumes are noted. The differential free swell is expressed by

$$\text{DFS} = \frac{\text{Soil volume in water } - \text{Soil volume in kerosine}}{\text{Soil volume in kerosine}}$$

3.6.5. UCS TEST :

Object: To determine the unconfined compressive strength of cohesive soil.

Appartus:

1. Unconfined apparatus , with proving ring
2. Dail gauge
3. Weighing balance
4. Oven
5. Mould(38 mm dia,76 mm long)
6. Knife

Procedure:

1. Prepare the soil and mix at desired water content.
2. Compact soil in mould with three layers by compaction road.
3. Saturate the sample.
4. Take out the sample from sampler.
5. Trim the two ends of soil specimem
6. Place specimen at bottom of compression machine
7. Adjust dial gauge and proing ring to zero.
8. Apply the load through compression mechine and record proving ring reading at equal interval of dial gauge reading upto failure of sample.

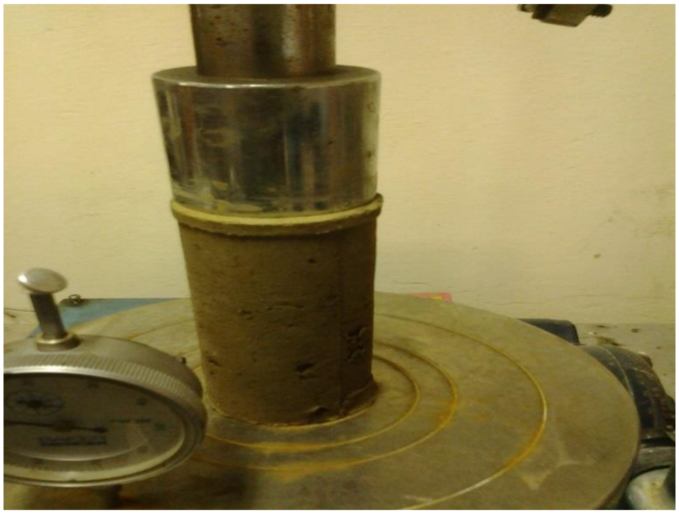

Fig 3.9 Loading of UCS sample

Fig 3.10 UCS samples

Fig 3.11 Failure of samples

CHAPTER 4

EXPERIMENTAL RESULT

4.1 SOIL STABILIZATION:

During the process of stabilization we alter the property of parent material by adding some admixtures in optimum dose so that they can get modify their engineering property economically. In my study i use Kota stone dust as a stabilizing material to stabilize black cotton soil and compare the result with stabilization of black cotton soil with Kota stone dust and fly ash, properties of materials are as given as

1. For Kota stone dust

   Liquid Limit = 34.19%

   Plastic Limit = 27.3 %

   Specific gravity= 2.59

   Maximum Dry Density= 1.321 g/cc

   Optimum moisture content = 23.1%

2. For fly ash

   Liquid Limit = 32%

   Plastic Limit = Non plastic

   Specific gravity= 2.13

   Maximum Dry Density= 1.35 g/cc

   Optimum moisture content = 19.0%

3. For Black cotton soil

   Liquid Limit = 53.53%

   Plastic Limit = 25.60%

   Specific gravity=2.71

   Maximum Dry Density= 1.68 g/cc

   Optimum moisture content = 14.50%

   UCS=0.120 MPa

4.2. CONSISTANCY LIMITS:

4.2.1. BCS+ 0% FA + 3% KSD

Liquid limit = 54.2%

Plastic limit = 26.2%

Plasticity Index = 28%

It has been observed that by addition of 3% KSD in Black cotton soil, increase in liquid limit was found 0.70% and increasing in plastic limit was found 0.60%.

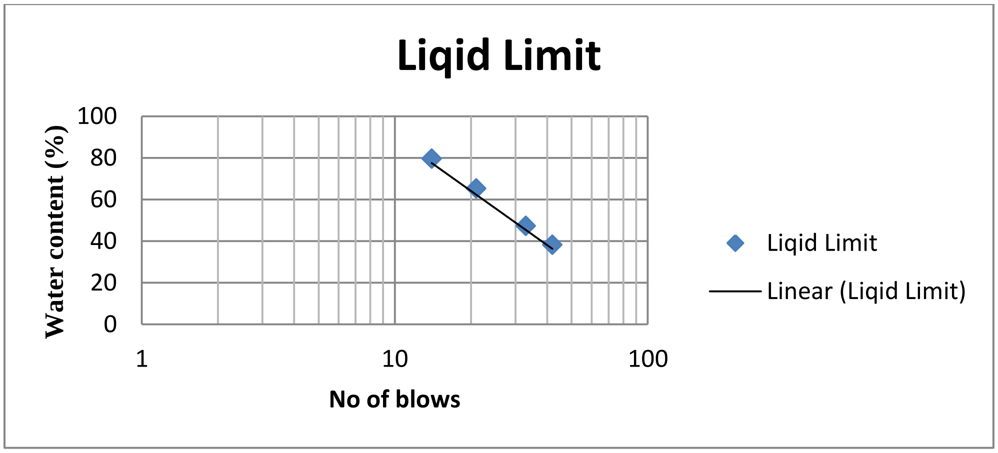

Fig 4.1 Liquid limit curve of Black Cotton Soil+ 0 % FA + 3%KSD

4.2.2. BCS+ 0% FA + 6% KSD

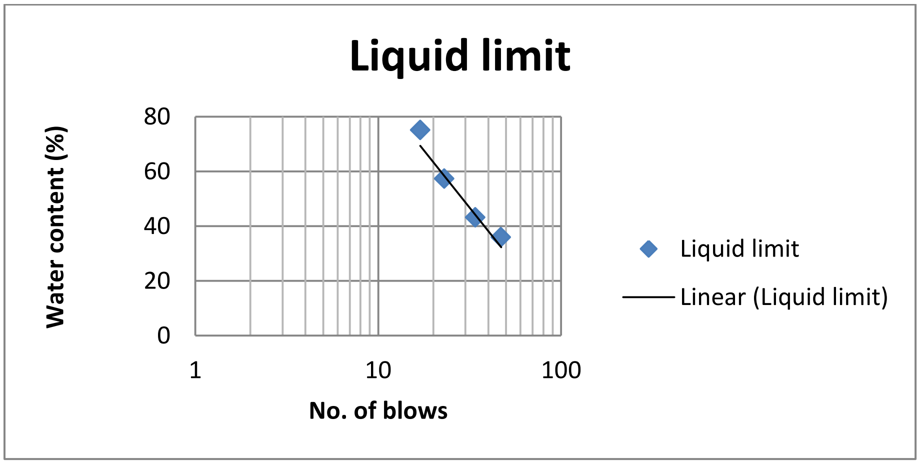

Fig 4.2 Liquid limit curve of Black Cotton Soil+ 0 % FA + 6%KSD

Liquid limit = 55.4%

Plastic limit = 26.8%

Plasticity Index = 28.6%

It has been observed that by addition of 6% KSD in Black cotton soil, increase in liquid limit was found 1.9% and increasing in plastic limit was found 1.2%.

4.2.3. BCS+ 0% FA + 9% KSD

Liquid limit = 56.7%

Plastic limit = 27.7%

Plasticity Index = 29%

It has been observed that by addition of 9% KSD in Black cotton soil, increase in liquid limit was found 3.2% and increasing in plastic limit was found 2.1%.

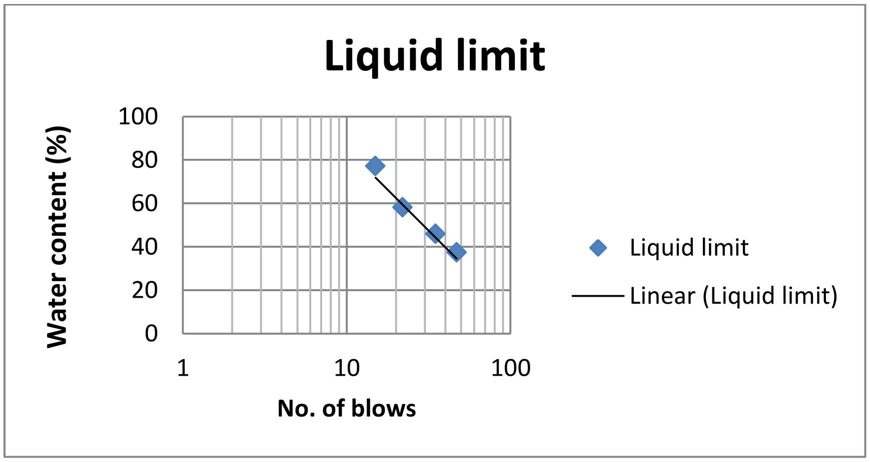

Fig 4.3 Liquid limit curve of Black Cotton Soil+ 0 % FA + 9%KSD

4.2.4. BCS+ 0% FA + 12% KSD

Liquid limit = 57.3%

Plastic limit = 28.4%

Plasticity Index = 28.9%

It has been observed that by addition of 3% KSD in Black cotton soil, increase in liquid limit was found 3.8% and increasing in plastic limit was found 2.8%.

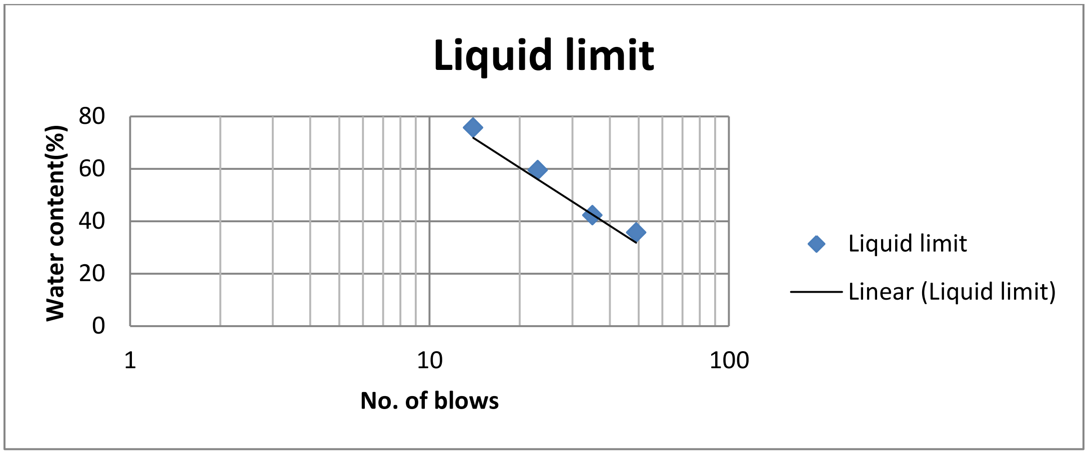

Fig 4.4 Liquid limit curve of Black Cotton Soil+ 0 % FA + 12%KSD

4.2.5. BCS+ 5% FA + 0% KSD

Liquid limit = 51.6%

Plastic limit = 24.3%

Plasticity Index = 27.3%

It has been observed that by addition of 3% KSD and 5 % FA in Black cotton soil, decrease in liquid limit was found 1.9% and decrease in plastic limit was found 1.3%.

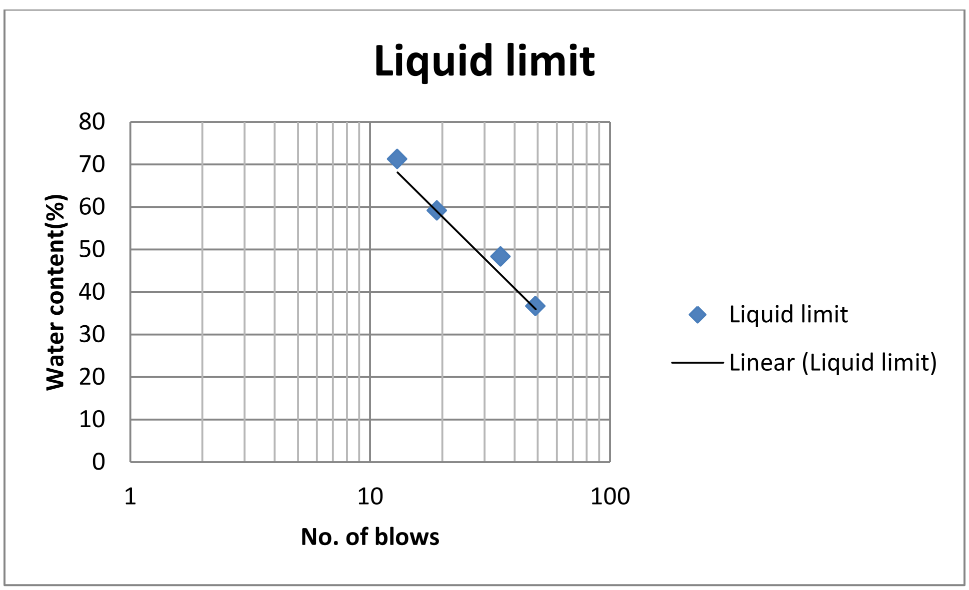

Fig 4.5 Liquid limit curve of Black Cotton Soil+5 % FA + 0%KSD

4.2.6. BCS+ 5% FA + 3% KSD

Liquid limit = 52.2%

Plastic limit = 24.7%

Plasticity Index = 27.5%

It has been observed that by addition of 3% KSD and 5 % FA in Black cotton soil, decrease in liquid limit was found 1.3% and decreasing in plastic limit was found 0.9%.

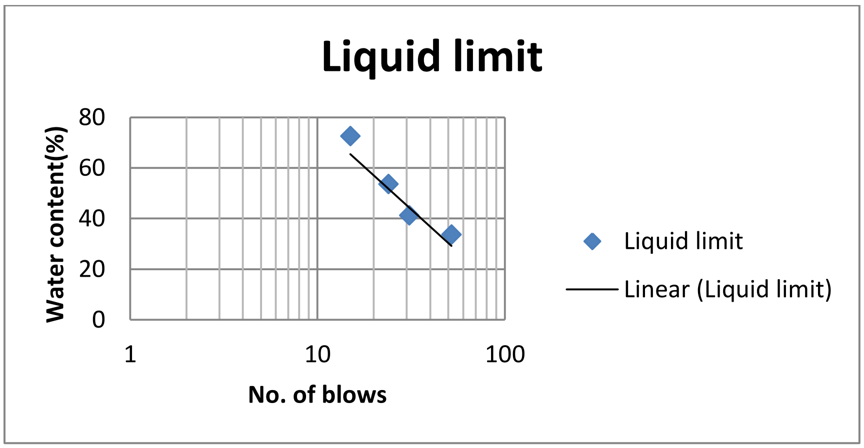

Fig 4.6 Liquid limit curve of Black Cotton Soil+ 5 % FA + 3%KSD

4.2.7. BCS+ 5% FA + 6% KSD

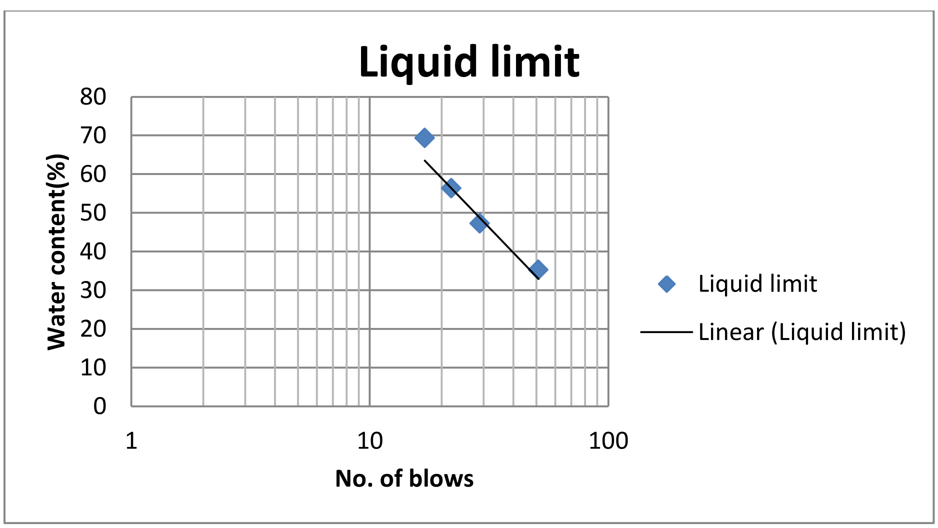

Fig 4.7 Liquid limit curve of Black Cotton Soil+ 5% FA +6%KSD

Liquid limit = 52.9%

Plastic limit = 25.5%

Plasticity Index = 27.4%

It has been observed that by addition of 3% KSD and 5 % FA in Black cotton soil, decrease in liquid limit was found 0.6% and decreasing in plastic limit was found 0.1%.

4.2.8. BCS+ 5% FA + 9% KSD

Liquid limit = 53.7%

Plastic limit = 26.2%

Plasticity Index = 27.5%

It has been observed that by addition of 9% KSD and 5 % FA in Black cotton soil,increase in liquid limit was found 0.2% and increasing in plastic limit was found 0.60%.

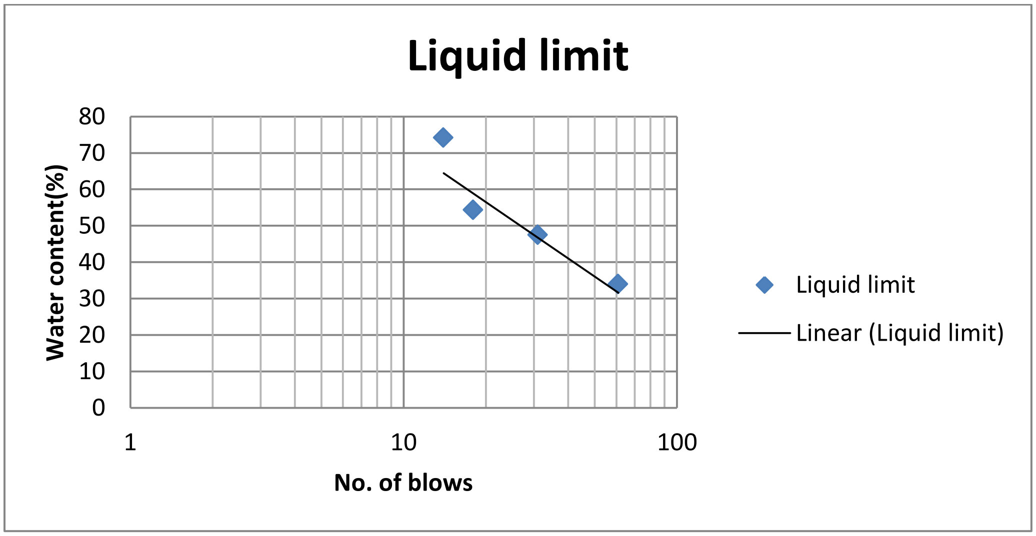

Fig 4.8 Liquid limit curve of Black Cotton Soil+ 5 % FA + 9%KSD

4.2.9. BCS+ 5% FA + 12% KSD

Liquid limit = 54.6%

Plastic limit = 26.8%

Plasticity Index = 27.8%

It has been observed that by addition of 12% KSD and 5 % FA in Black cotton soil, increase in liquid limit was found 1.1% and increasing in plastic limit was found 1.2%.

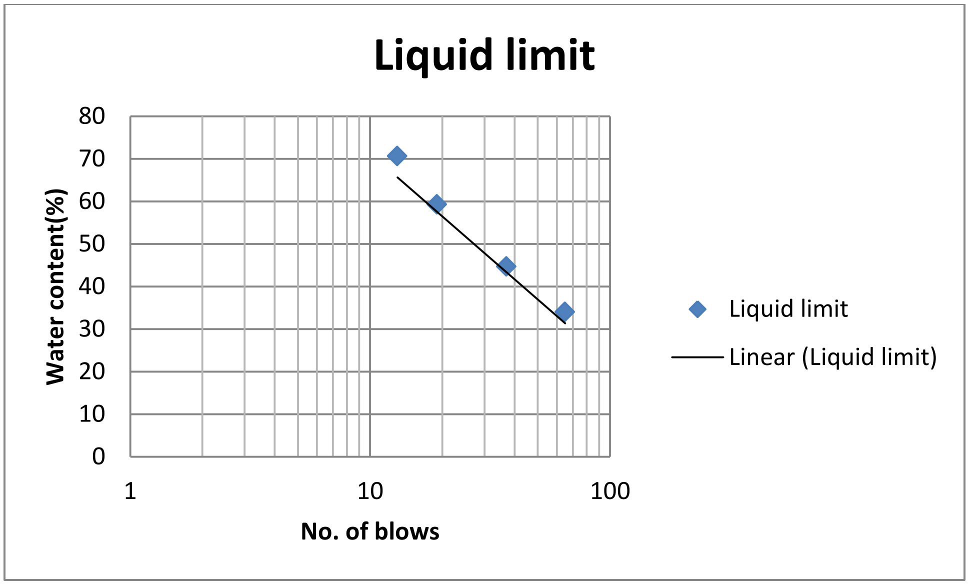

Fig 4.9 Liquid limit curve of Black Cotton Soil+ 5 % FA + 12%KSD

4.2.10. BCS+ 10% FA + 0% KSD

Liquid limit =47.2%

Plastic limit = 22.8%

Plasticity Index = 24.4%

It has been observed that by addition of 0% KSD and 10 % FA in Black cotton soil, decrease in liquid limit was found 6% and decreasing in plastic limit was found 2.8%.

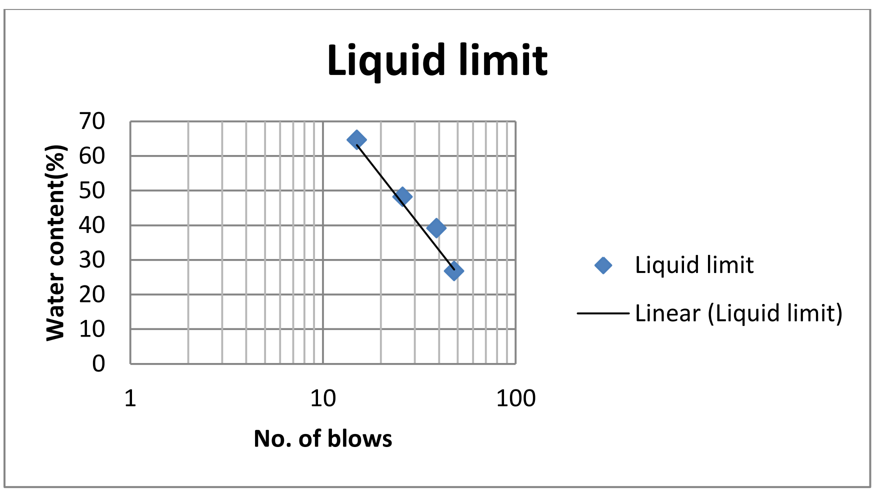

Fig 4.10 Liquid limit curve of Black Cotton Soil+1 0 % FA + 0%KSD

4.2.11. BCS+ 10% FA + 3% KSD

Liquid limit = 48.4%

Plastic limit = 23.2%

Plasticity Index = 25.2%

It has been observed that by addition of 3% KSD and 10 % FA in Black cotton soil, decrease in liquid limit was found 5.1% and decreasing in plastic limit was found 2.4%.

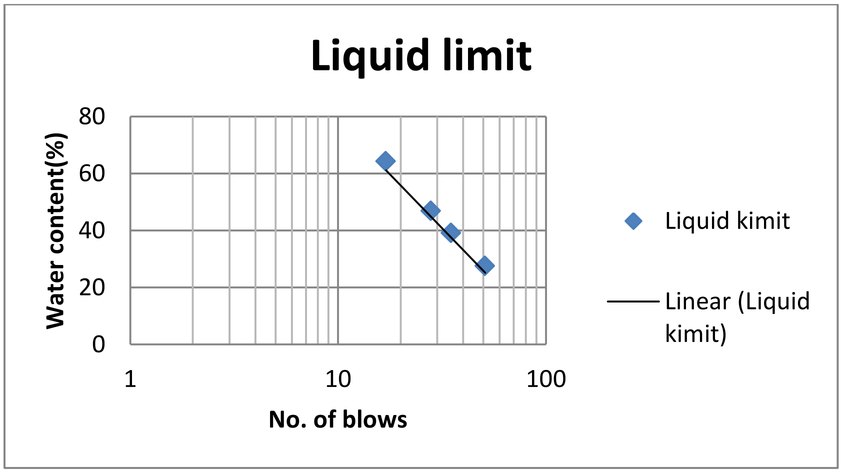

Fig 4.11 Liquid limit curve of Black Cotton Soil+ 10 % FA + 3%KSD

4.2.12. BCS+ 10% FA + 6% KSD

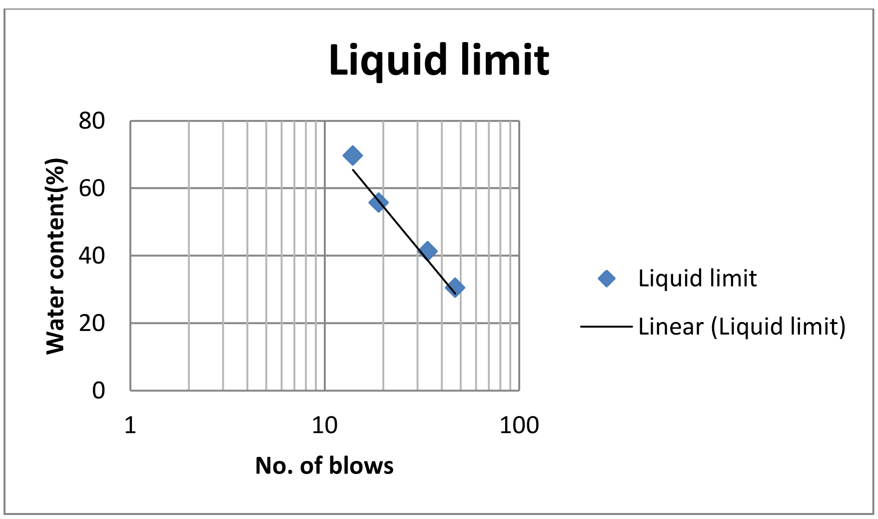

Fig 4.12 Liquid limit curve of Black Cotton Soil+1 0 % FA +6%KSD

Liquid limit = 49.7%

Plastic limit = 23.4%

Plasticity Index = 26.3%

It has been observed that by addition of 6% KSD and 10% FA in Black cotton soil, decrease in liquid limit was found 3.8% and decreasing in plastic limit was found 2.4%.

4.2.13. BCS+ 10% FA + 9% KSD

Liquid limit = 50.3%

Plastic limit = 23.8%

Plasticity Index = 26.5%

It has been observed that by addition of 9% KSD and 10% FA in Black cotton soil, decrease in liquid limit was found 3.2% and decreasing in plastic limit was found 2.6%.

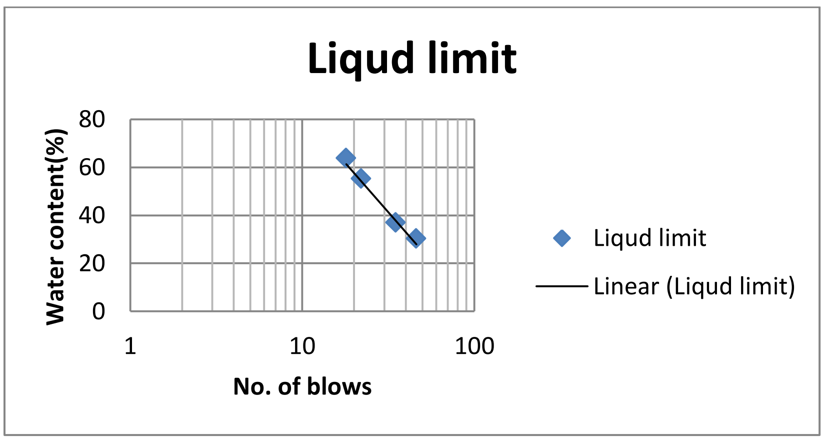

Fig 4.13 Liquid limit curve of Black Cotton Soil+1 0 % FA + 9%KSD

4.2.14. BCS+ 10% FA + 12% KSD

Liquid limit = 50.1%

Plastic limit = 24.3%

Plasticity Index = 25.8%

It has been observed that by addition of 12% KSD and 10% FA in Black cotton soil, decrease in liquid limit was found 3.4% and decreasing in plastic limit was found 1.3%.

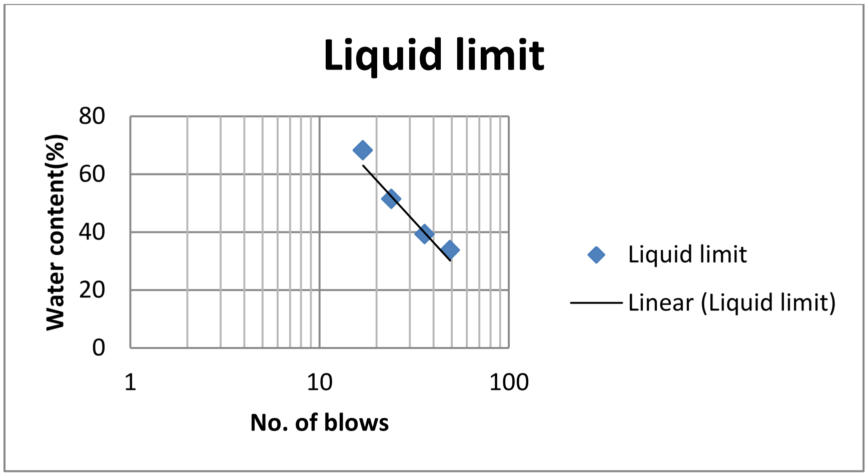

Fig 4.14 Liquid limit curve of Black Cotton Soil+10 % FA + 12%KSD

4.2.15. BCS+ 15% FA + 0% KSD

Liquid limit = 42.6%

Plastic limit = 21.4%

Plasticity Index = 21.2%

It has been observed that by addition of 0% KSD and 15% FA in Black cotton soil, decrease in liquid limit was found 10.9% and decreasing in plastic limit was found 4.2%.

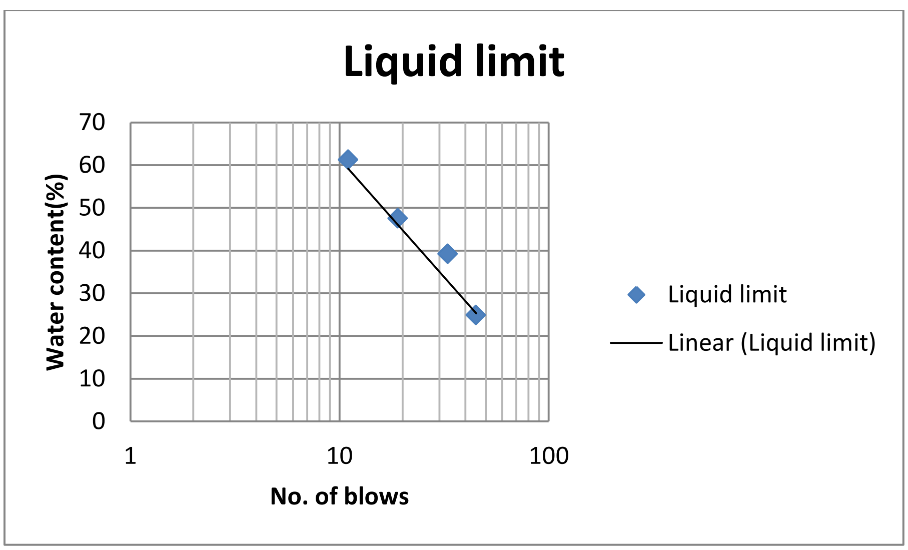

Fig 4.15 Liquid limit curve of Black Cotton Soil+ 15 % FA + 0%KSD

4.2.16. BCS+ 15% FA + 3% KSD

Liquid limit = 43.2%

Plastic limit = 21.4%

Plasticity Index = 21.8%

It has been observed that by addition of 3% KSD and 15% FA in Black cotton soil, decrease in liquid limit was found 10.3% and decreasing in plastic limit was found 4.0%.

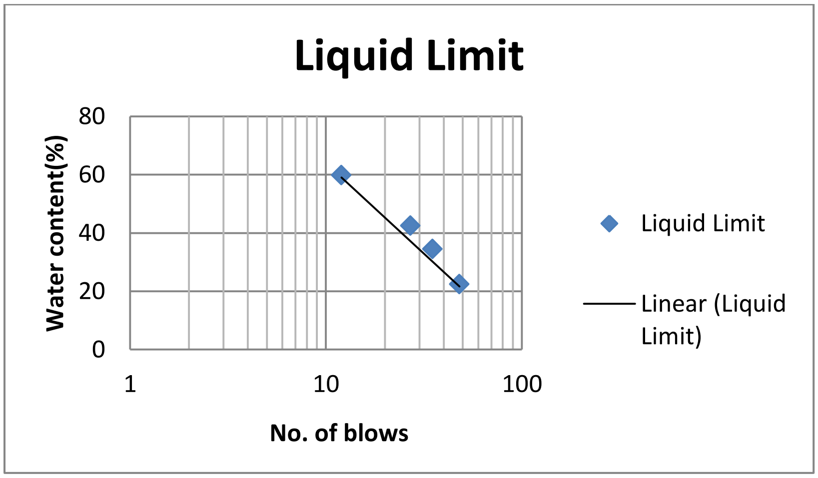

Fig 4.16 Liquid limit curve of Black Cotton Soil+ 15 % FA + 3%KSD

4.2.17. BCS+ 15% FA + 6% KSD

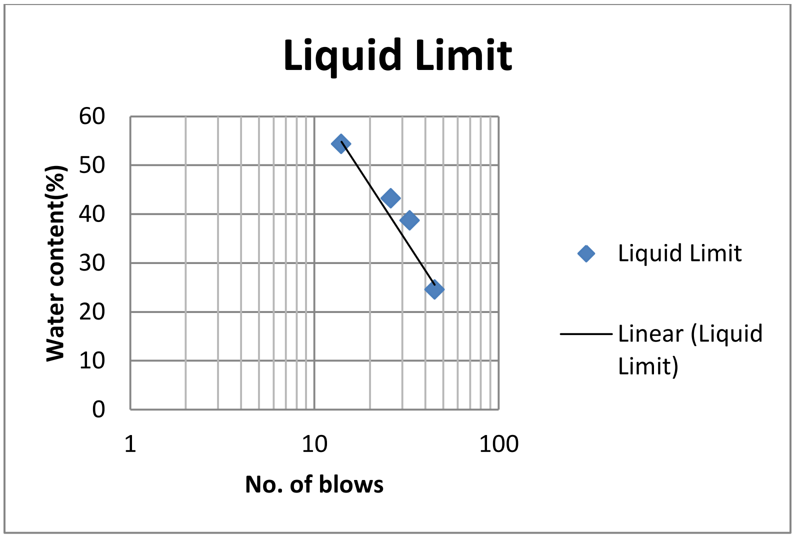

Fig 4.17 Liquid limit curve of Black Cotton Soil+ 15 % FA +6%KSD

Liquid limit = 43.7%

Plastic limit = 21.6%

Plasticity Index = 21.1%

It has been observed that by addition of 6% KSD and 15% FA in Black cotton soil, decrease in liquid limit was found 9.8% and decreasing in plastic limit was found 3.4%.

4.2.18. BCS+ 15% FA + 9% KSD

Liquid limit = 42.5%

Plastic limit = 22.02%

Plasticity Index = 22.3%

It has been observed that by addition of 9% KSD and 15% FA in Black cotton soil, decrease in liquid limit was found 9% and decreasing in plastic limit was found 3.58%.

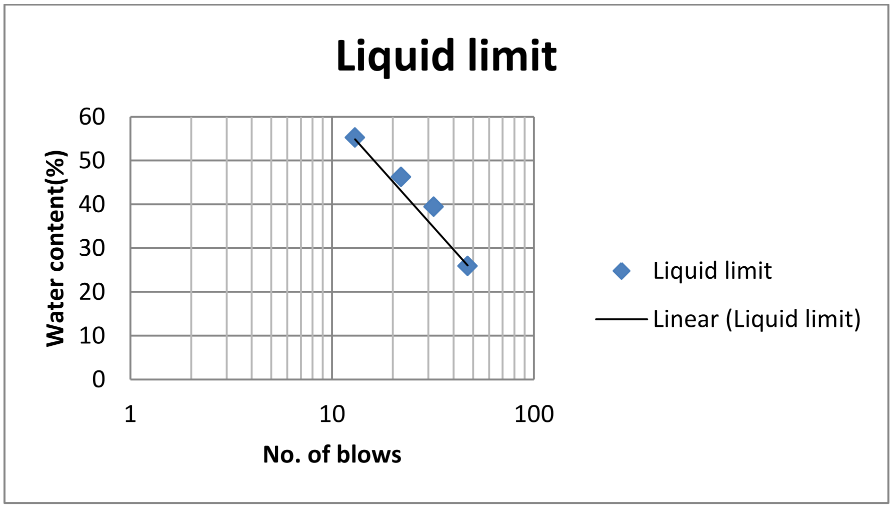

Fig4.18 Liquid limit curve of Black Cotton Soil+ 15 % FA + 9%KSD

4.2.19. BCS+ 15% FA + 12% KSD

Liquid limit = 45.2%

Plastic limit = 22.7%

Plasticity Index = 22.5%

It has been observed that by addition of 12% KSD and 15% FA in Black cotton soil, decrease in liquid limit was found 8.3% and decreasing in plastic limit was found 2.9%.

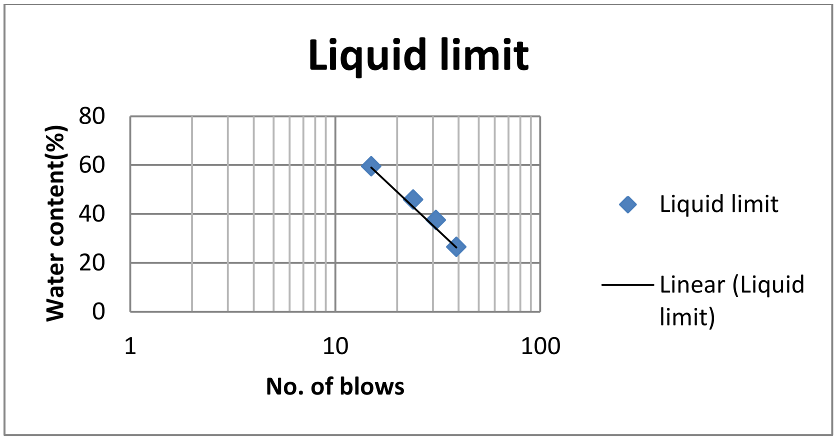

Fig 4.19 Liquid limit curve of Black Cotton Soil+ 15 % FA + 12%KSD

4.3.FREE SWELL INDEX TEST RESULT:

4.3.1. BCS+ 0% FA + 3% KSD

Initial volume in water=6.4ml

Initial volume in kerosene=6.4ml

Final volume in water=8.2ml

Final volume in kerosene=6.4ml

Free Swell Index=28.13%

It has been observed that by addition of 3% KSD in Black cotton soil, decrease in FSI was found 18.75% .

4.3.2. BCS+ 0% FA + 6% KSD

Initial volume in water=6.4ml

Initial volume in kerosene=6.4ml

Final volume in water=7.8ml

Final volume in kerosene=6.4ml

Free Swell Index=21.88%

It has been observed that by addition of 6% KSD and 0 % FA in Black cotton soil, decrease in FSI was found 25% .

4.3.3. BCS+ 0% FA + 9% KSD

Initial volume in water=6.2ml

Initial volume in kerosene=6.2ml

Final volume in water=7.6ml

Final volume in kerosene=6.2ml

Free Swell Index=22.58%

It has been observed that by addition of 0% KSD and 9% FA in Black cotton soil, decrease in FSI was found 24.3% .

4.3.4. BCS+ 0% FA + 12% KSD

Initial volume in water=6.2ml

Initial volume in kerosene=6.2ml

Final volume in water=7.8ml

Final volume in kerosene=6.2ml

Free Swell Index=25.8%

It has been observed that by addition of 12% KSD and 0% FA in Black cotton soil, decrease in FSI was found 21.08% .

4.3.5. BCS+ 5% FA + 0% KSD

Initial volume in water=6.6ml

Initial volume in kerosene=6.6ml

Final volume in water=8.8ml

Final volume in kerosene=6.6ml

Free Swell Index=33.33%

It has been observed that by addition of 0% KSD and 5% FA in Black cotton soil, decrease in FSI was found 13.55% .

4.3.6. BCS+ 5% FA + 3% KSD

Initial volume in water=6.6ml

Initial volume in kerosene=6.6ml

Final volume in water=8ml

Final volume in kerosene=6.6ml

Free Swell Index=21.22%

It has been observed that by addition of 3% KSD and 5% FA in Black cotton soil, decrease in FSI was found 25.67% .

4.3.7. BCS+ 5% FA + 6% KSD

Initial volume in water=6.4ml

Initial volume in kerosene=6.4ml

Final volume in water=7.6ml

Final volume in kerosene=6.4ml

Free Swell Index=18.75%

It has been observed that by addition of 6 % KSD and 5% FA in Black cotton soil, decrease in FSI was found 28.13% .

4.3.8. BCS+ 5% FA + 9% KSD

Initial volume in water=6.4ml

Initial volume in kerosene=6.4ml

Final volume in water=7.6ml

Final volume in kerosene=6.4ml

Free Swell Index=18.75%

It has been observed that by addition of 9% KSD and 5% FA in Black cotton soil, decrease in FSI was found 28.13% .

4.3.9. BCS+ 5% FA + 12% KSD

Initial volume in water=6.4ml

Initial volume in kerosene=6.4ml

Final volume in water=7.8ml

Final volume in kerosene=6.4ml

Free Swell Index=21.88%

It has been observed that by addition of 12% KSD and 5% FA in Black cotton soil, decrease in FSI was found 25% .

4.3.10. BCS+ 10% FA + 0% KSD

Initial volume in water=6.6ml

Initial volume in kerosene=6.6ml

Final volume in water=8.4ml

Final volume in kerosene=6.6ml

Free Swell Index=27.27%

It has been observed that by addition of 0 % KSD and 10% FA in Black cotton soil, decrease in FSI was found 19.61% .

4.3.11. BCS+ 10% FA + 3% KSD

Initial volume in water=6.4ml

Initial volume in kerosene=6.4ml

Final volume in water=7.4ml

Final volume in kerosene=6.4ml

Free Swell Index=18.75%

It has been observed that by addition of 3% KSD and 10% FA in Black cotton soil, decrease in FSI was found 28.13% .

4.3.12. BCS+ 10% FA + 6% KSD

Initial volume in water=6.4ml

Initial volume in kerosene=6.4ml

Final volume in water=7.4ml

Final volume in kerosene=6.4ml

Free Swell Index=15.63%

It has been observed that by addition of 6% KSD and 10% FA in Black cotton soil, decrease in FSI was found 31.25% .

4.3.13. BCS+ 10% FA + 9% KSD

Initial volume in water=6.2ml

Initial volume in kerosene=6.2ml

Final volume in water=7ml

Final volume in kerosene=6.2ml

Free Swell Index=12.9%

It has been observed that by addition of 9% KSD and 10% FA in Black cotton soil, decrease in FSI was found 33.98% .

4.3.14. BCS+ 10% FA + 12% KSD

Initial volume in water=6.4ml

Initial volume in kerosene=6.4ml

Final volume in water=7.4ml

Final volume in kerosene=6.4ml

Free Swell Index=15.63%

It has been observed that by addition of 12% KSD and 10% FA in Black cotton soil, decrease in FSI was found 31.25% .

4.3.15. BCS+ 15% FA + 0% KSD

Initial volume in water=6.8ml

Initial volume in kerosene=6.8ml

Final volume in water=9.4ml

Final volume in kerosene=6.8ml

Free Swell Index=38.24%

It has been observed that by addition of 0% KSD and 15% FA in Black cotton soil, decrease in FSI was found 8.64% .

4.3.16. BCS+ 15% FA + 3% KSD

Initial volume in water=6.8ml

Initial volume in kerosene=6.8ml

Final volume in water=8.8ml

Final volume in kerosene=6.8ml

Free Swell Index=29.41%

It has been observed that by addition of 3% KSD and 15% FA in Black cotton soil, decrease in FSI was found 17.47% .

4.3.17. BCS+ 15% FA + 6% KSD

Initial volume in water=6.6ml

Initial volume in kerosene=6.6ml

Final volume in water=8.4ml

Final volume in kerosene=6.6ml

Free Swell Index=26.78%

It has been observed that by addition of 6% KSD and 15% FA in Black cotton soil, decrease in FSI was found 20.1% .

4.3.18. BCS+ 15% FA + 9% KSD

Initial volume in water=6.6ml

Initial volume in kerosene=6.6ml

Final volume in water=8.4ml

Final volume in kerosene=6.6ml

Free Swell Index=26.78%

It has been observed that by addition of 9% KSD and 15% FA in Black cotton soil, decrease in FSI was found 201% .

4.3.19. BCS+ 15% FA + 12% KSD

Initial volume in water=6.6ml

Initial volume in kerosene=6.6ml

Final volume in water=8.4ml

Final volume in kerosene=6.6ml

Free Swell Index=26.78%

It has been observed that by addition of 12% KSD and 15% FA in Black cotton soil, decrease in FSI was found 20.1% .

4.4 STANDARD PROCTOR TEST RESULT:

4.4.1. BCS+ 0% FA + 3% KSD:

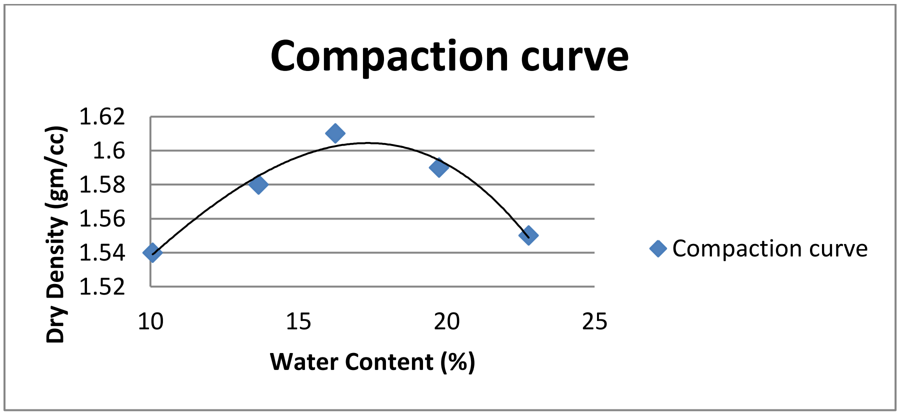

Fig 4.20 Compaction curve of Black Cotton Soil+ 0% FA + 3%KSD

From the graph it has been observed that maximum dry density of Black cotton soil was decreased by 0.07g/cc and optimum moisture content of Black cotton soil was increased by 1.5% by addition of 3% KSD.

Optimum moisture content W = 16%

Max. Dry density $(\rho_d)_{max}$ = 1.61 g/cc

4.4.2. BCS+ 0% FA + 6% KSD

From the graph it has been observed that maximum dry density of Black cotton soil was decreased by 0.16g/cc and optimum moisture content of Black cotton soil was increased by 3% by addition of 6% KSD.

Optimum moisture content W = 18.5%

Max. Dry density $(\rho_d)_{max}$ = 1.52 g/cc

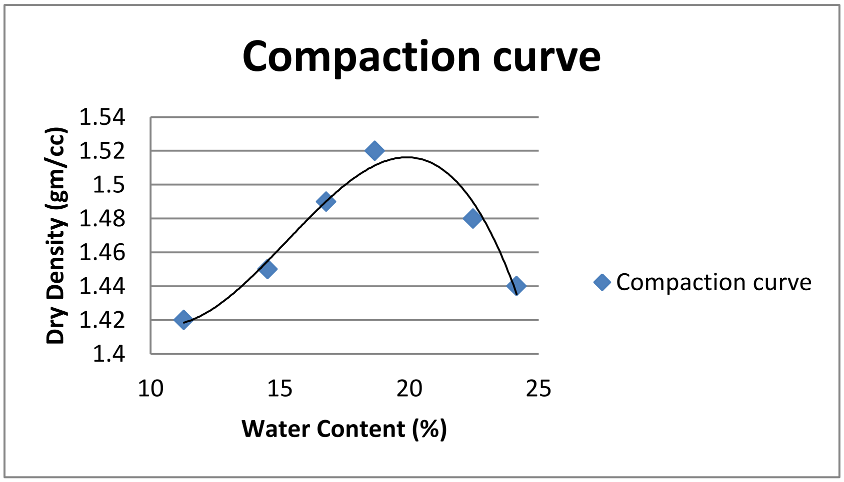

Fig 4.21 Compaction curve of Black Cotton Soil+ 0% FA + 6%KSD

4.4.3. BCS+ 0% FA + 9% KSD

From the graph it has been observed that maximum dry density of Black cotton soil was decreased by 0.24g/cc and optimum moisture content of Black cotton soil was increased by 8% by addition of 9% KSD.

Optimum moisture content W = 22.5%

Max. Dry density $(\rho_d)_{max}$ = 1.44 g/cc

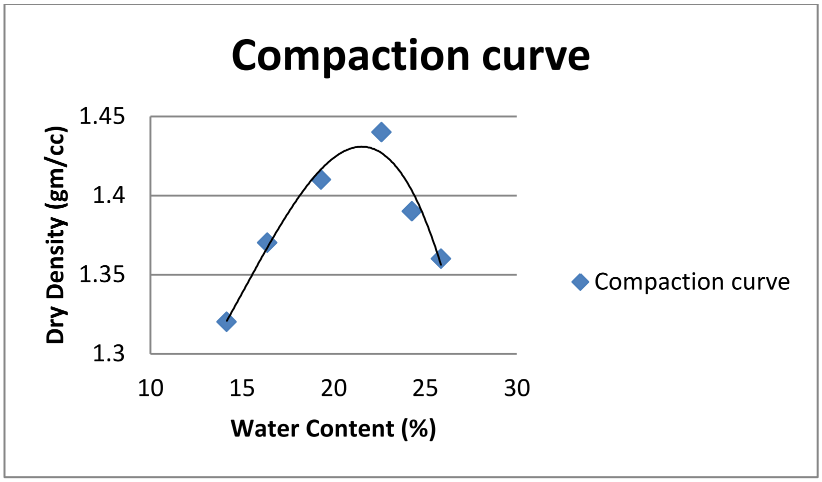

Fig 4.22 Compaction curve of Black Cotton Soil+ 0% FA + 9%KSD

4.4.4. BCS+ 0% FA + 12% KSD

From the graph it has been observed that maximum dry density of Black cotton soil was decreased by 0.28g/cc and optimum moisture content of Black cotton soil was increased by 9.5% by addition of 12% KSD.

Optimum moisture content W = 24%

Max. Dry density $(\rho_d)_{max}$ = 1.40 g/cc

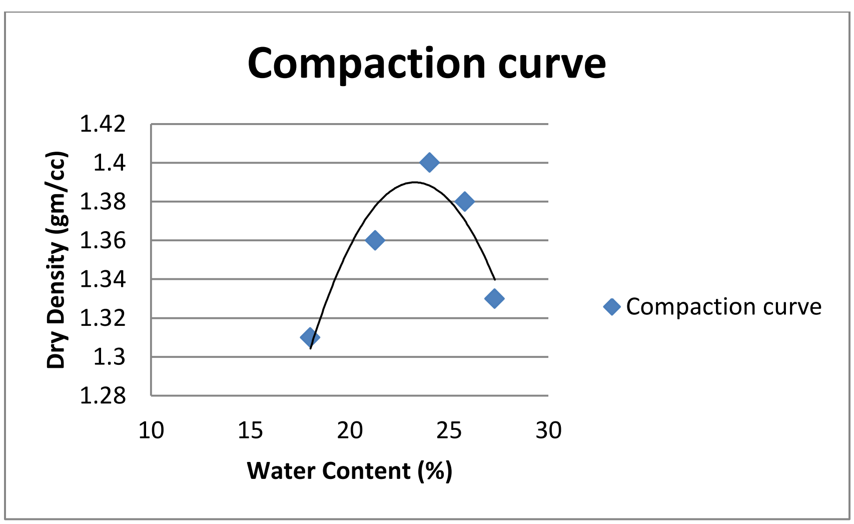

Fig 4.23 Compaction curve of Black Cotton Soil+ 0% FA + 12%KSD

4.4.5. BCS+ 5% FA + 0% KSD

From the graph it has been observed that maximum dry density of Black cotton soil was decreased by 0.05g/cc and optimum moisture content of Black cotton soil was increased by 3% by addition of 0% KSD and 5% FA.

Optimum moisture content W = 17.5%

Max. Dry density $(\rho_d)_{max}$ = 1.63 g/cc

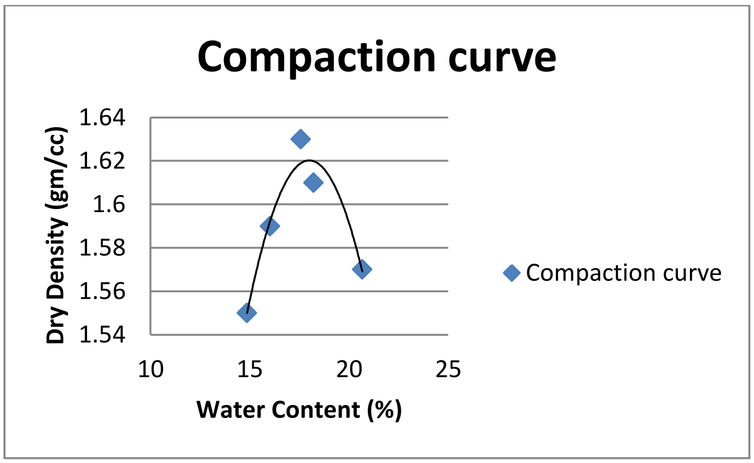

Fig 4.24 Compaction curve of Black Cotton Soil+ 5% FA + 0%KSD

4.4.6. BCS+ 5% FA + 3% KSD

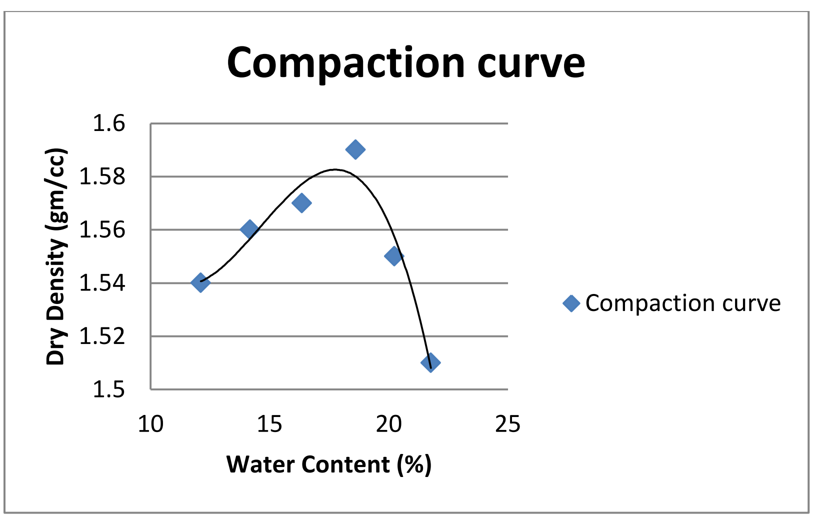

Fig 4.25 Compaction curve of Black Cotton Soil+ 5% FA + 3%KSD

From the graph it has been observed that maximum dry density of Black cotton soil was decreased by 0.09g/cc and optimum moisture content of Black cotton soil was increased by 4.1% by addition of 3% KSD and 5% FA.

Optimum moisture content W = 18.6%

Max. Dry density $(\rho_d)_{max}$ = 1.59 g/cc

4.4.7. BCS+ 5% FA + 6% KSD

From the graph it has been observed that maximum dry density of Black cotton soil was decreased by 0.14g/cc and optimum moisture content of Black cotton soil was increased by 5.7% by addition of 6% KSD and 5% FA.

Optimum moisture content W = 20.2%

Max. Dry density $(\rho_d)_{max}$ = 1.54 g/cc

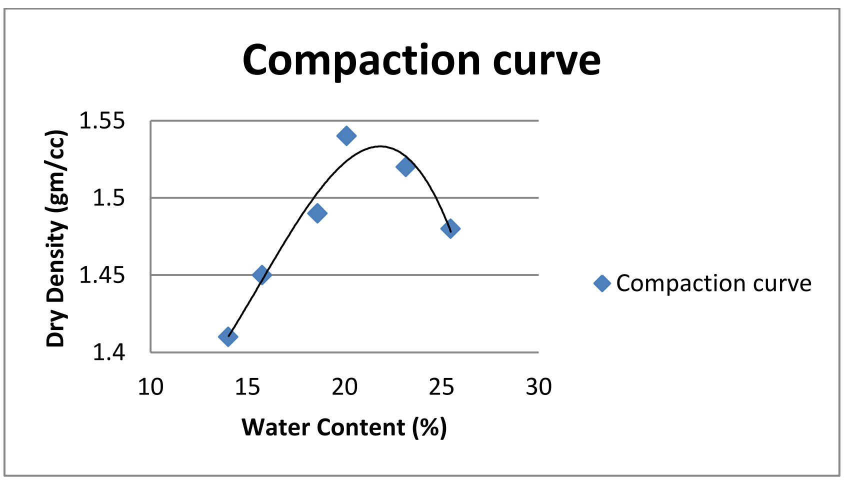

Fig 4.26 Compaction curve of Black Cotton Soil+ 5% FA + 6%KSD

4.4.8. BCS+ 5% FA + 9% KSD

From the graph it has been observed that maximum dry density of Black cotton soil was decreased by 0.2g/cc and optimum moisture content of Black cotton soil was increased by 7.9% by addition of 9% KSD and 5% FA.

Optimum moisture content W = 22.4%

Max. Dry density $(\rho_d)_{max}$ = 1.48 g/cc

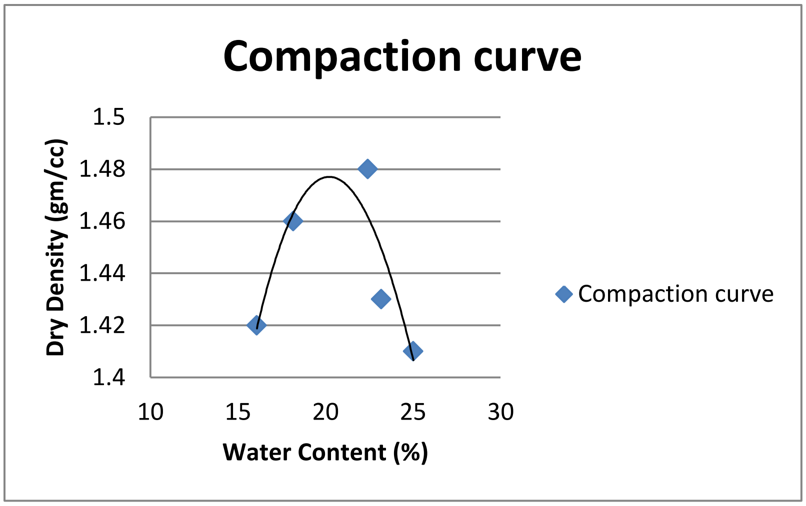

Fig 4.27 Compaction curve of Black Cotton Soil+ 5% FA + 9%KSD

4.4.9. BCS+ 5% FA + 12% KSD

From the graph it has been observed that maximum dry density of Black cotton soil was decreased by 0.26g/cc and optimum moisture content of Black cotton soil was increased by 10% by addition of 12% KSD and 5% FA.

Optimum moisture content W = 24.5%

Max. Dry density $(\rho_d)_{max}$ = 1.42 g/cc

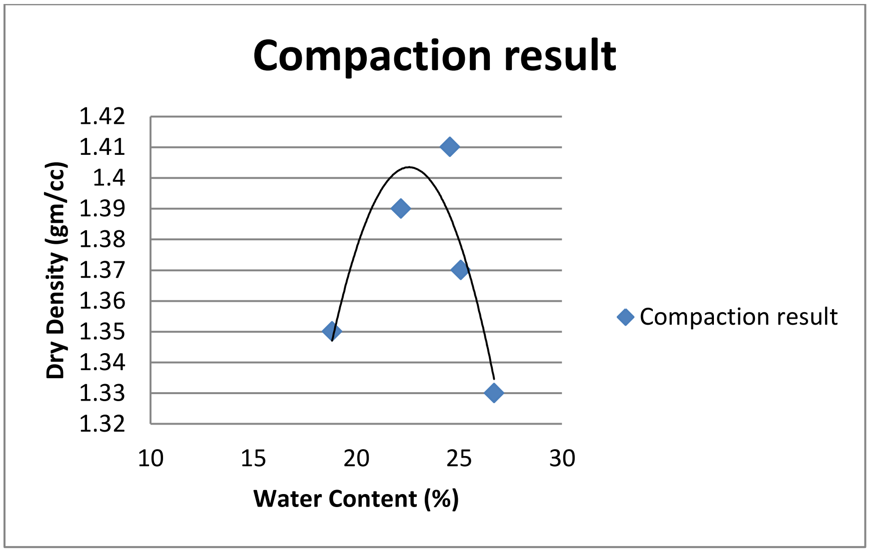

Fig 4.28 Compaction curve of Black Cotton Soil+ 5% FA + 12%KSD

4.4.10. BCS+ 10% FA + 0% KSD

From the graph it has been observed that maximum dry density of Black cotton soil was decreased by 0.12g/cc and optimum moisture content of Black cotton soil was increased by 2.7% by addition of 0% KSD and 10% FA.

Optimum moisture content W = 17.2%

Max. Dry density $(\rho_d)_{max}$ = 1.56 g/cc

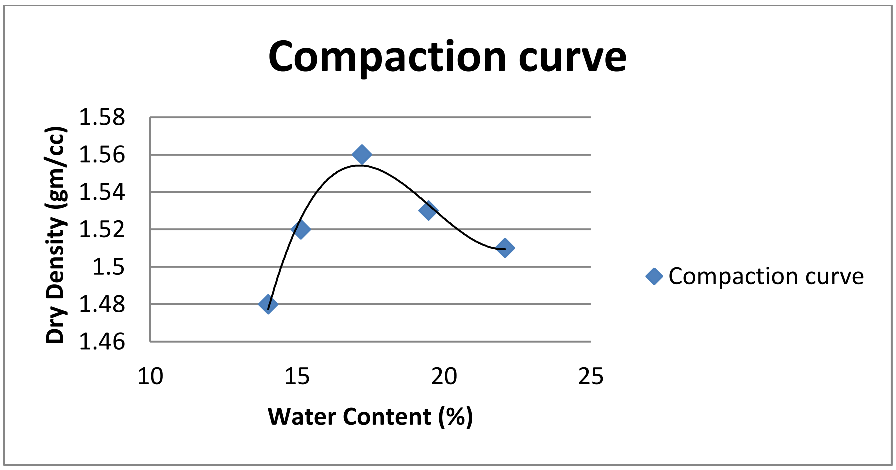

Fig 4.29 Compaction curve of Black Cotton Soil+ 10% FA + 0%KSD

4.4.11. BCS+ 10% FA + 3% KSD

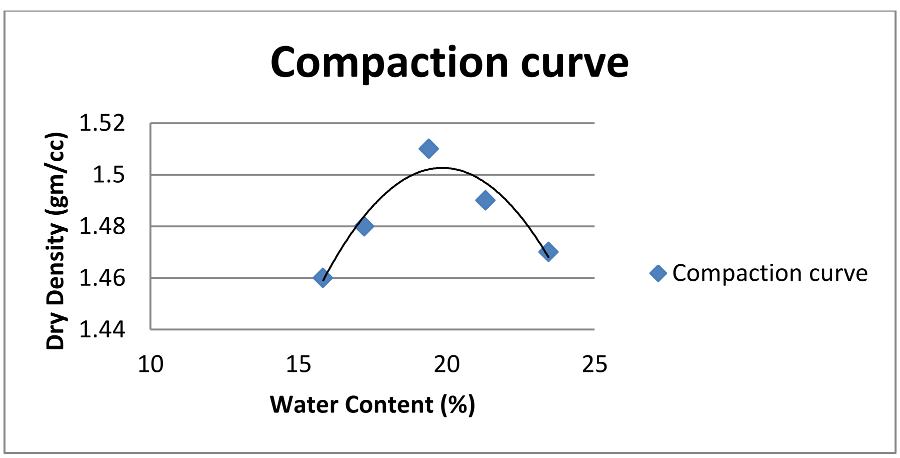

Fig 4.30 Compaction curve of Black Cotton Soil+ 10% FA + 3%KSD

From the graph it has been observed that maximum dry density of Black cotton soil was decreased by 0.17g/cc and optimum moisture content of Black cotton soil was increased by 4.9% by addition of 3% KSD and 10% FA.

Optimum moisture content W = 19.4%

Max. Dry density $(\rho_d)_{max}$ = 1.51 g/cc

4.4.12. BCS+ 10% FA + 6% KSD

From the graph it has been observed that maximum dry density of Black cotton soil was decreased by 0.21g/cc and optimum moisture content of Black cotton soil was increased by 6.8% by addition of 6% KSD and 10 % FA.

Optimum moisture content W = 21.3%

Max. Dry density $(\rho_d)_{max}$ = 1.47 g/cc

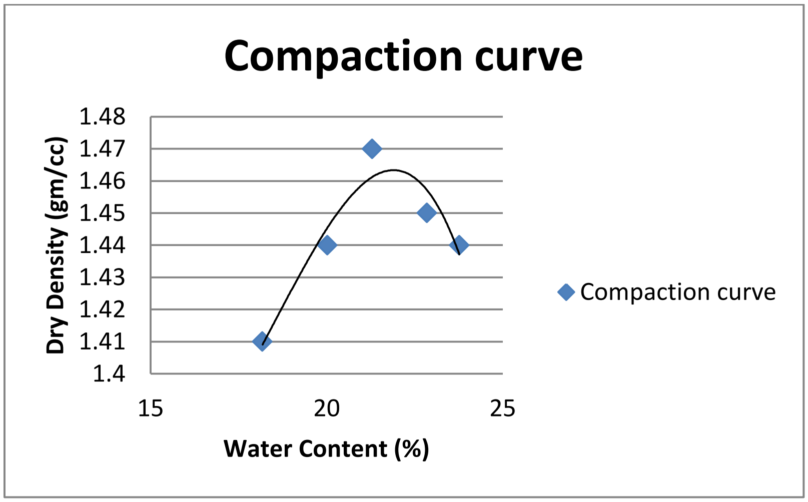

Fig 4.31 Compaction curve of Black Cotton Soil+ 10% FA + 6%KSD

4.4.13. BCS+ 10% FA + 9% KSD

From the graph it has been observed that maximum dry density of Black cotton soil was decreased by 0.27g/cc and optimum moisture content of Black cotton soil was increased by 8.7% by addition of 9% KSD and 0% FA.

Optimum moisture content W = 23.2%

Max. Dry density $(\rho_d)_{max}$ = 1.41 g/cc

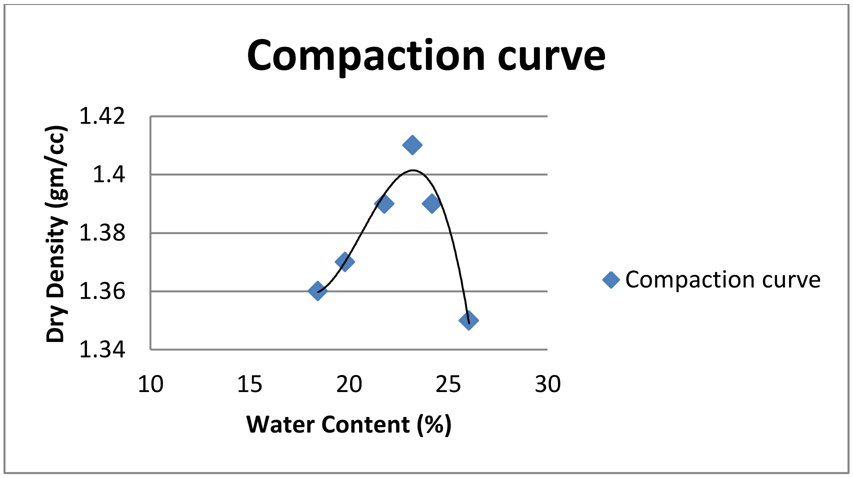

Fig 4.32 Compaction curve of Black Cotton Soil+ 10% FA + 9%KSD

4.4.14. BCS+ 10% FA + 12% KSD

From the graph it has been observed that maximum dry density of Black cotton soil was decreased by 0.31g/cc and optimum moisture content of Black cotton soil was increased by 10.3% by addition of 12% KS and 10% FA.

Optimum moisture content W = 24.8%

Max. Dry density $(\rho_d)_{max}$ = 1.37 g/cc

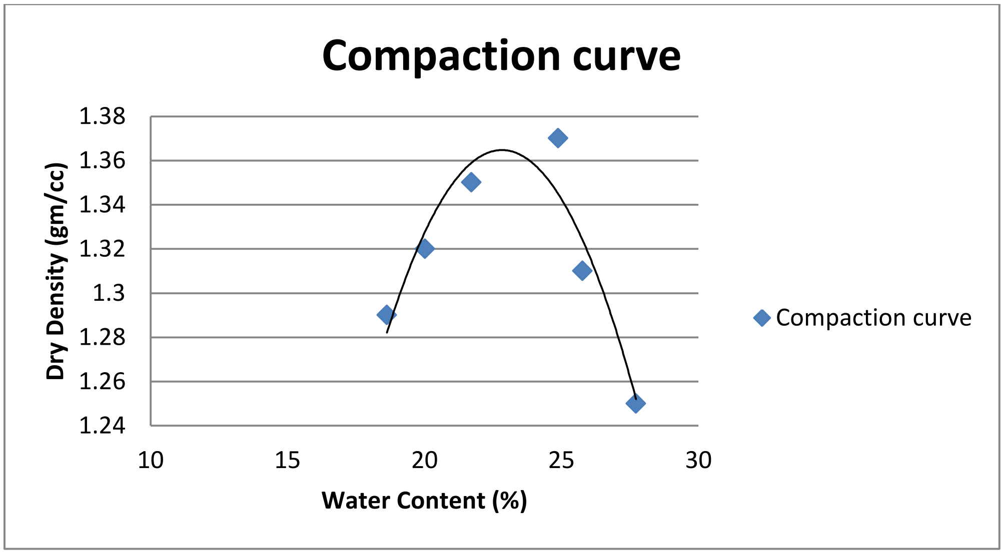

Fig 4.33 Compaction curve of Black Cotton Soil+ 10% FA + 12%KSD

4.4.15. BCS+ 15% FA + 0% KSD

From the graph it has been observed that maximum dry density of Black cotton soil was decreased by 0.19g/cc and optimum moisture content of Black cotton soil was increased by 5.8% by addition of 0% KSD and 15 % FA.

Optimum moisture content W = 20.3%

Max. Dry density $(\rho_d)_{max}$ = 1.49 g/cc

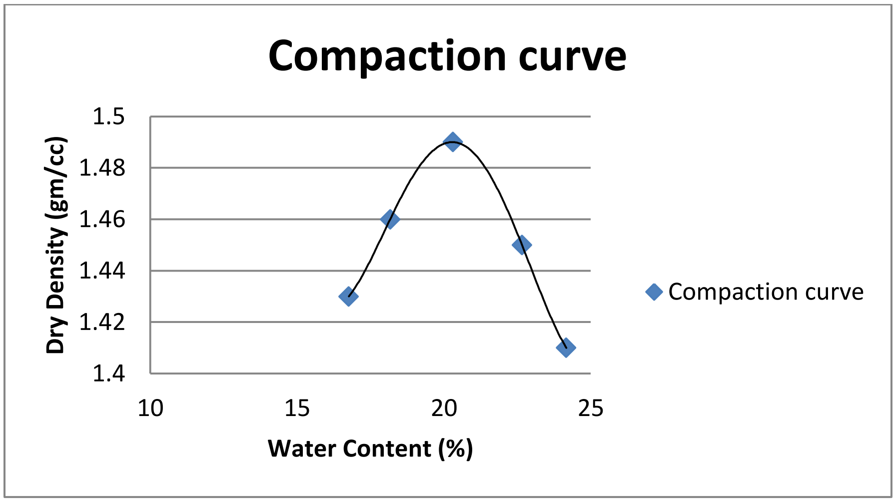

Fig 4.34 Compaction curve of Black Cotton Soil+ 15% FA + 0%KSD

4.4.16. BCS+ 15% FA + 3% KSD

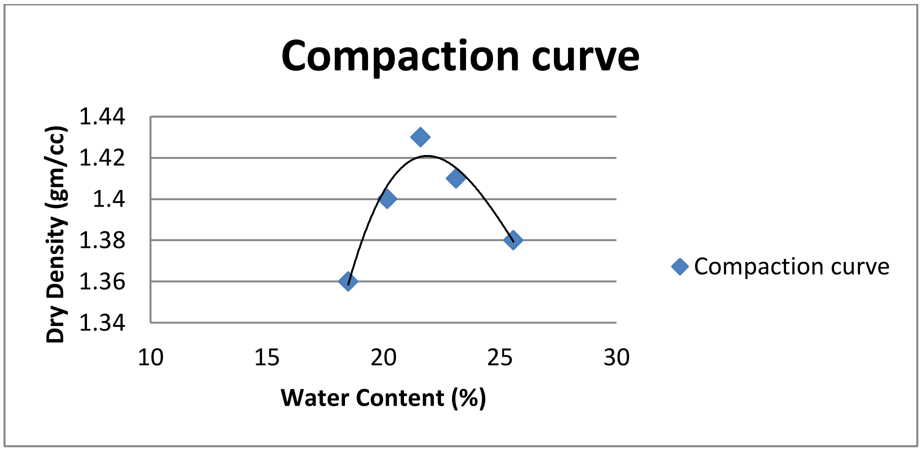

Fig 4.35 Compaction curve of Black Cotton Soil+ 15% FA + 3%KSD

From the graph it has been observed that maximum dry density of Black cotton soil was decreased by 0.25g/cc and optimum moisture content of Black cotton soil was increased by 7.1% by addition of 3% KSD and 15% FA.

Optimum moisture content W = 21.6%

Max. Dry density $(\rho_d)_{max}$ = 1.43 g/cc

4.4.17. BCS+ 15% FA + 6% KSD

From the graph it has been observed that maximum dry density of Black cotton soil was decreased by 0.3g/cc and optimum moisture content of Black cotton soil was increased by 8.3% by addition of 3% KSD and 15% FA.

Optimum moisture content W = 22.8%

Max. Dry density $(\rho_d)_{max}$ = 1.38 g/cc

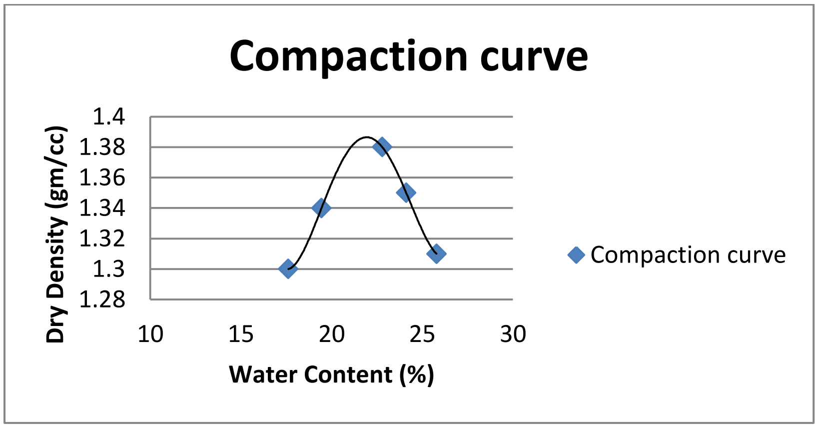

Fig 4.36 Compaction curve of Black Cotton Soil+ 15% FA + 6%KSD

4.4.18. BCS+ 15% FA + 9% KSD

From the graph it has been observed that maximum dry density of Black cotton soil was decreased by 0.34g/cc and optimum moisture content of Black cotton soil was increased by 9.7% by addition of 9% KSD and 15% FA.

Optimum moisture content W = 24.2%

Max. Dry density $(\rho_d)_{max}$ = 1.34 g/cc

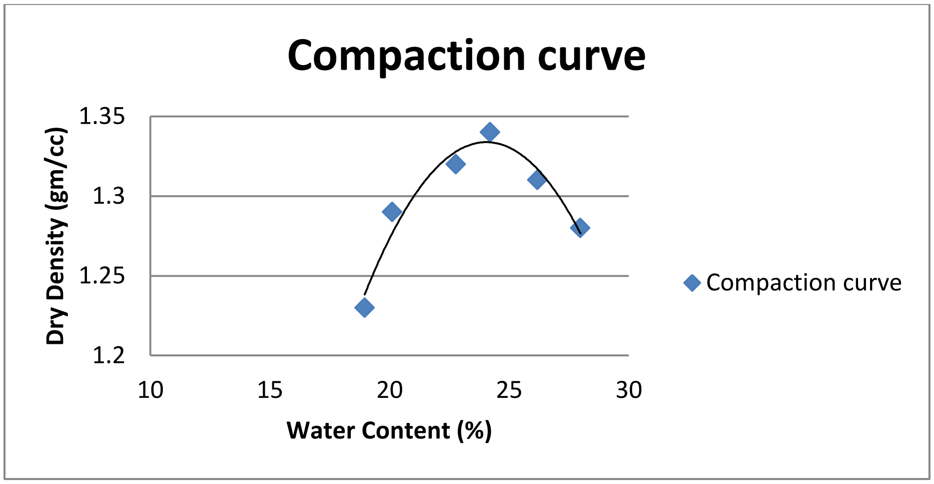

Fig 4.37 Compaction curve of Black Cotton Soil+ 15% FA + 9%KSD

4.4.19. BCS+ 15% FA + 12% KSD

From the graph it has been observed that maximum dry density of Black cotton soil was decreased by 0.36g/cc and optimum moisture content of Black cotton soil was increased by 11.1% by addition of 12% KSD and 15% FA.

Optimum moisture content W = 25.6%

Max. Dry density $(\rho_d)_{max}$ = 1.32 g/cc

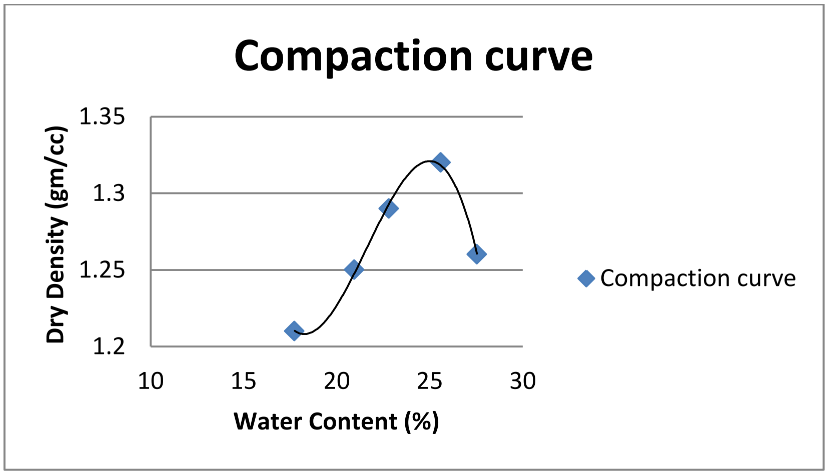

Fig 4.38 Compaction curve of Black Cotton Soil+ 15% FA + 12%KSD

4.5. UCS TEST RESULT:

4.5.1. BCS+ 0% FA + 3% KSD

From the graph it has been observed that UCS of Black cotton soil was increased by 4.79 KPa for 1 day,30.83KPa for 7 days and 52.38KPa for 28 days by addition of 3% KSD and 0% FA.

UCS for 1 day = 84.08KPa

UCS for 7 days=149.77KPa

UCS for 28 days=187.70KPa

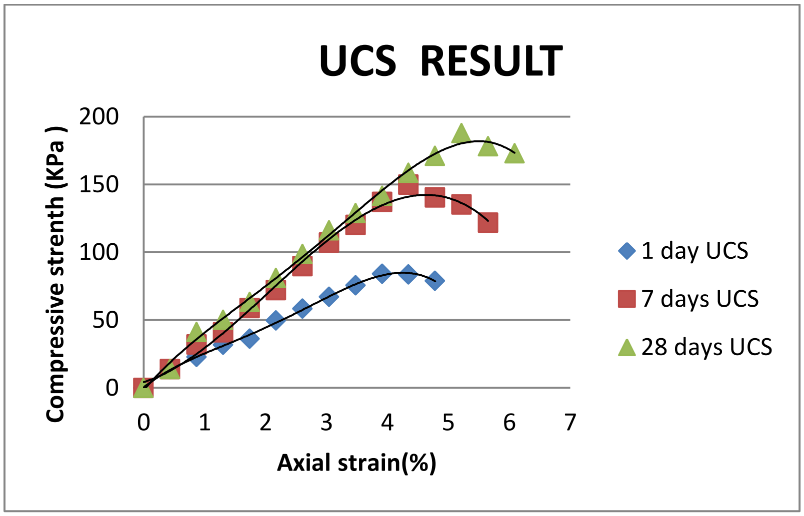

Fig 4.39 UCS curve of Black Cotton Soil+ 0% FA + 3%KSD

4.5.2. BCS+ 0% FA + 6% KSD

From the graph it has been observed that UCS of Black cotton soil was decreased by 7.53 KPa for 1 day,increase by 16.38KPa for 7 days and 57.63KPa for 28 days by addition of 6% KSD and 0% FA.

UCS for 1 day = 71.76KPa

UCS for 7 days=135.32KPa

UCS for 28 days=192.95KPa

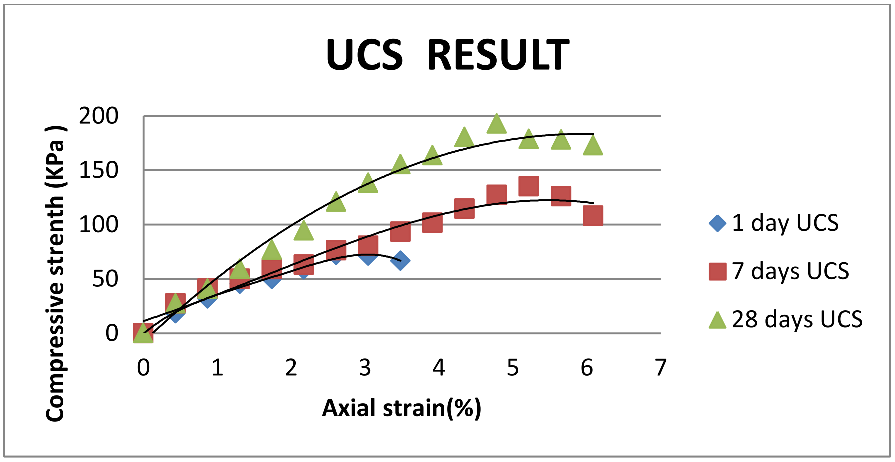

Fig 4.40 UCS curve of Black Cotton Soil+ 0% FA + 6%KSD

4.5.3. BCS+ 0% FA + 9% KSD

From the graph it has been observed that UCS of Black cotton soil was increased by 0 KPa for 1 day, decrease by 17.62KPa for 7 days and increase by 23.27KPa for 28 days by addition of 9% KSD and 0% FA.

UCS for 1 day = 79.29KPa

UCS for 7 days=101.32KPa

UCS for 28 days=158.59KPa

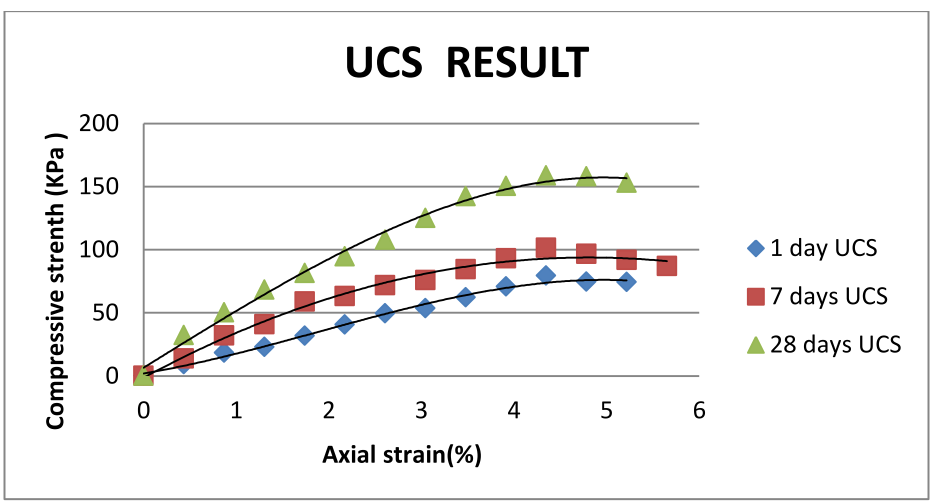

Fig 4.41 UCS curve of Black Cotton Soil+ 0% FA + 9%KSD

4.5.4. BCS+ 0% FA + 12% KSD

From the graph it has been observed that UCS of Black cotton soil was decreased by 12.01 KPa for 1 day,34.09KPa for 7 days and increased by 1.24KPa for 28 days by addition of 12% KSD and 0% FA.

UCS for 1 day = 67.28KPa

UCS for 7 days=84.85KPa

UCS for 28 days=136.56KPa

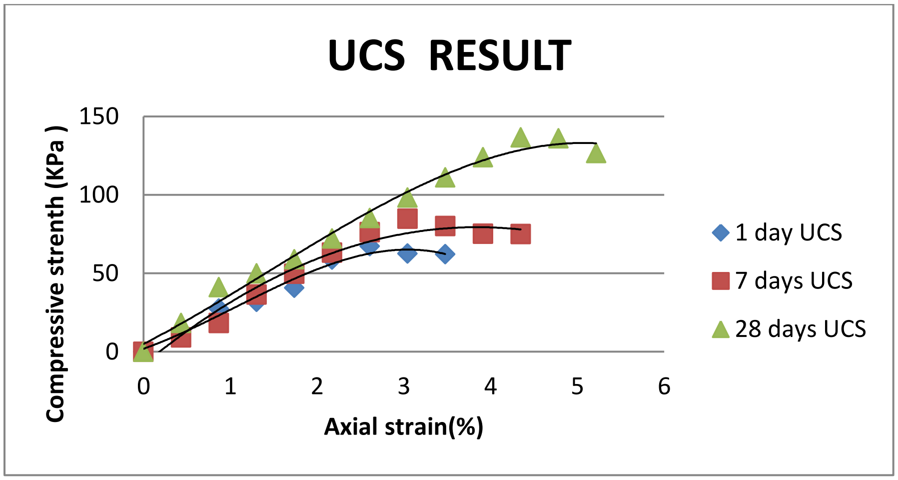

Fig 4.42 UCS curve of Black Cotton Soil+ 0% FA + 12%KSD

4.5.5. BCS+ 5% FA + 0% KSD

From the graph it has been observed that UCS of Black cotton soil was increased by 1.08 KPa for 1 day,4.4KPa for 7 days and 23.26KPa for 28 days by addition of 0% KSD and 5% FA.

UCS for 1 day = 80.37KPa

UCS for 7 days=123.34KPa

UCS for 28 days=158.58KPa

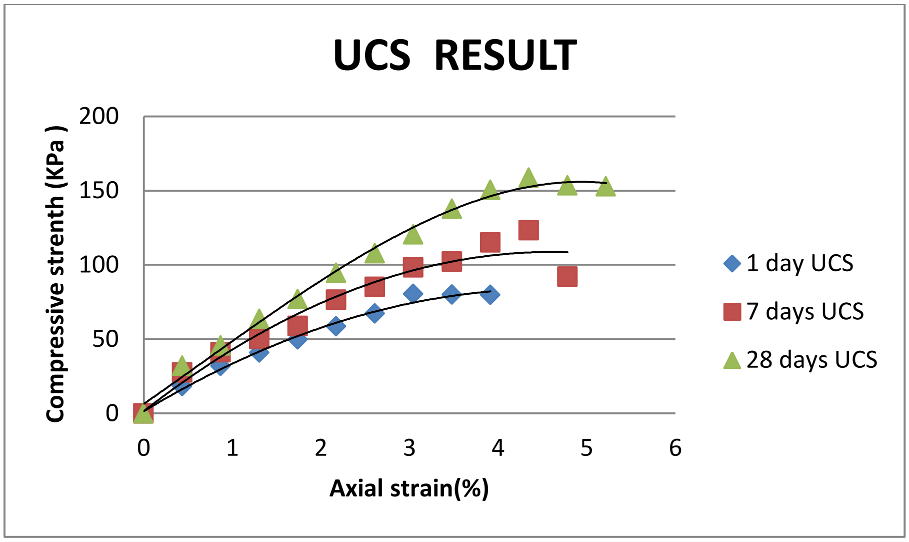

Fig 4.43 UCS curve of Black Cotton Soil+ 5% FA + 0%KSD

4.5.6. BCS+ 5% FA + 3% KSD

From the graph it has been observed that UCS of Black cotton soil was increased by 9.22 KPa for 1 day,30.15KPa for 7 days and 35.7KPa for 28 days by addition of 3% KSD and 5% FA.

UCS for 1 day = 88.51KPa

UCS for 7 days=1149.09KPa

UCS for 28 days=171.02KPa

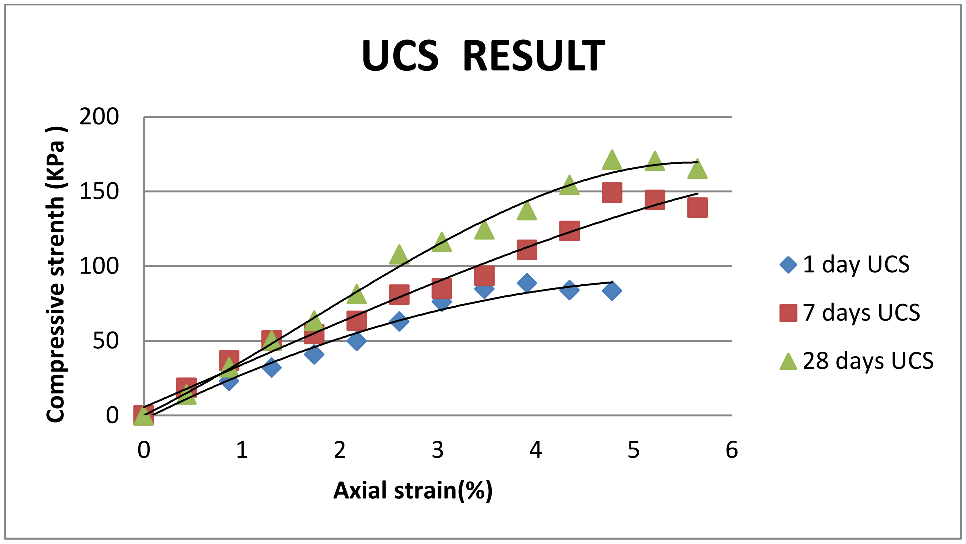

Fig 4.44 UCS curve of Black Cotton Soil+ 5% FA + 3%KSD

4.5.7. BCS+ 5% FA + 6% KSD

From the graph it has been observed that UCS of Black cotton soil was increased by 4.41 KPa for 1 day,51.3KPa for 7 days and 57.63KPa for 28 days by addition of 6% KSD and 5% FA.

UCS for 1 day = 83.70KPa

UCS for 7 days=170.24KPa

UCS for 28 days=192.95KPa

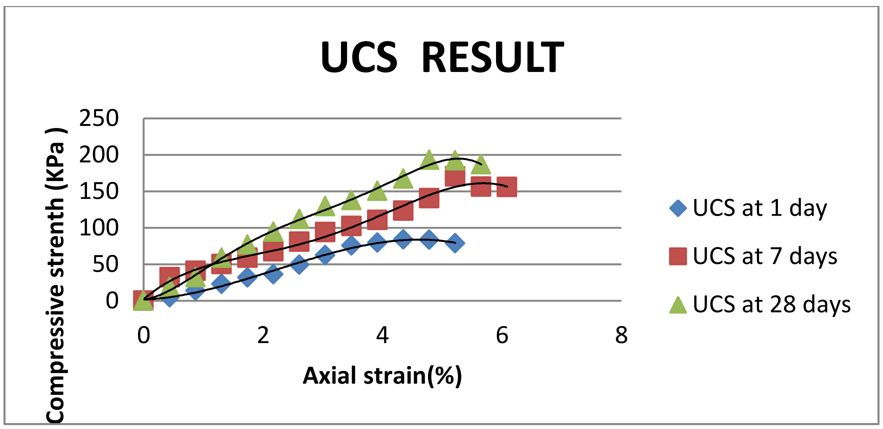

Fig 4.45 UCS curve of Black Cotton Soil+ 5% FA + 6%KSD

4.5.8. BCS+ 5% FA + 9% KSD

From the graph it has been observed that UCS of Black cotton soil was increased by 13.22 KPa for 1 day,34.54KPa for 7 days and 48.86KPa for 28 days by addition of 9% KSD and 5% FA.

UCS for 1 day = 92.51KPa

UCS for 7 days=153.48KPa

UCS for 28 days=184.18KPa

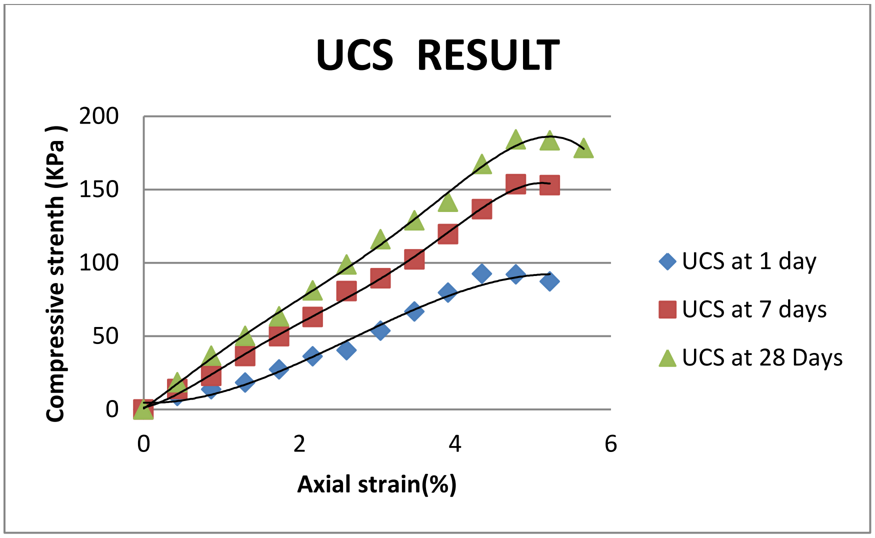

Fig 4.46 UCS curve of Black Cotton Soil+ 5% FA + 9%KSD

4.5.9. BCS+ 5% FA + 12% KSD

From the graph it has been observed that UCS of Black cotton soil was decreased by 3.72 KPa for 1 day,3.88KPa for 7 days and increased by 31.32KPa for 28 days by addition of 12% KSD and 5% FA.

UCS for 1 day = 75.57KPa

UCS for 7 days=1115.06KPa

UCS for 28 days=166.64KPa

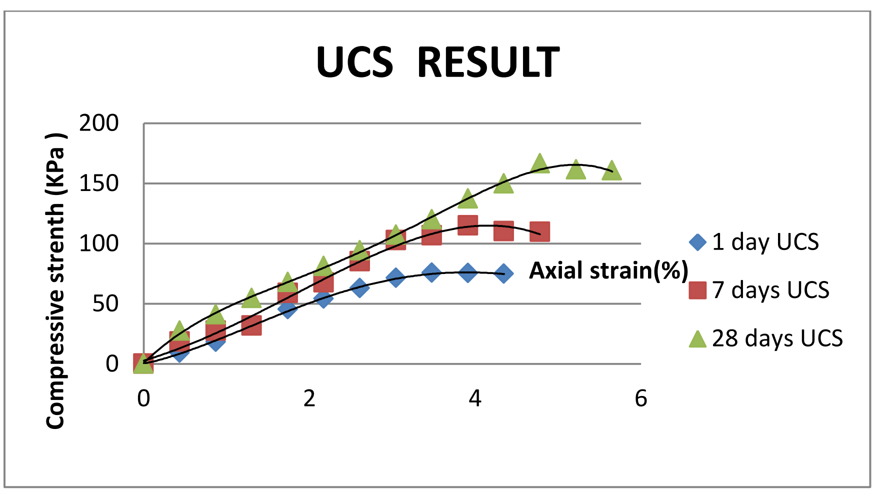

Fig 4.47 UCS curve of Black Cotton Soil+ 5% FA + 12%KSD

4.5.10. BCS+ 10% FA + 0% KSD

From the graph it has been observed that UCS of Black cotton soil was increased by 1.44 KPa for 1 day,14.4KPa for 7 days and 36.27KPa for 28 days by addition of 0% KSD and 10% FA.

UCS for 1 day = 80.73KPa

UCS for 7 days=133.34KPa

UCS for 28 days=172.59KPa

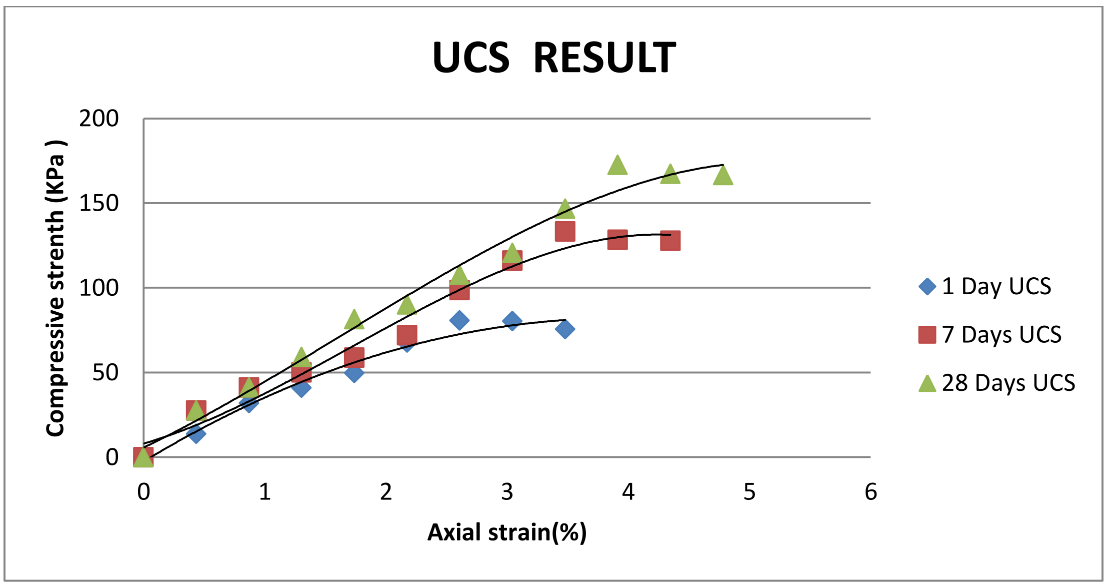

Fig 4.48 UCS curve of Black Cotton Soil+ 10% FA + 0%KSD

4.5.11. BCS+ 10% FA + 3% KSD

From the graph it has been observed that UCS of Black cotton soil was increased by 4.79 KPa for 1 day,18.86KPa for 7 days and 54.11KPa for 28 days by addition of 3% KSD and 10% FA.

UCS for 1 day = 84.08KPa

UCS for 7 days=137.80KPa

UCS for 28 days=189.43KPa

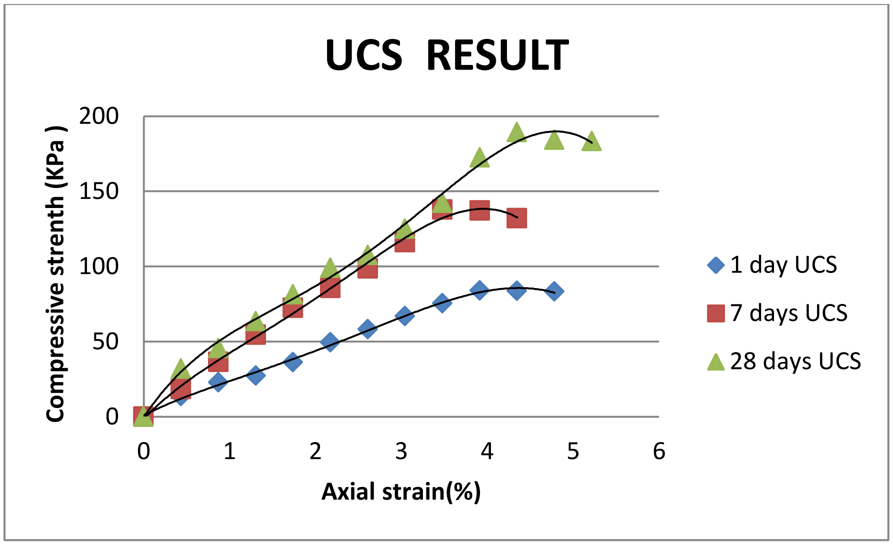

Fig 4.49 UCS curve of Black Cotton Soil+ 10% FA + 3%KSD

4.5.12. BCS+ 10% FA + 6% KSD

From the graph it has been observed that UCS of Black cotton soil was increased by 13.22 KPa for 1 day, 43.96 KPa for 7 days and 80.54 KPa for 28 days by addition of 6% KSD and 10% FA.

UCS for 1 day = 92.51 KPa

UCS for 7 days=162.90 KPa

UCS for 28 days=215.86 KPa

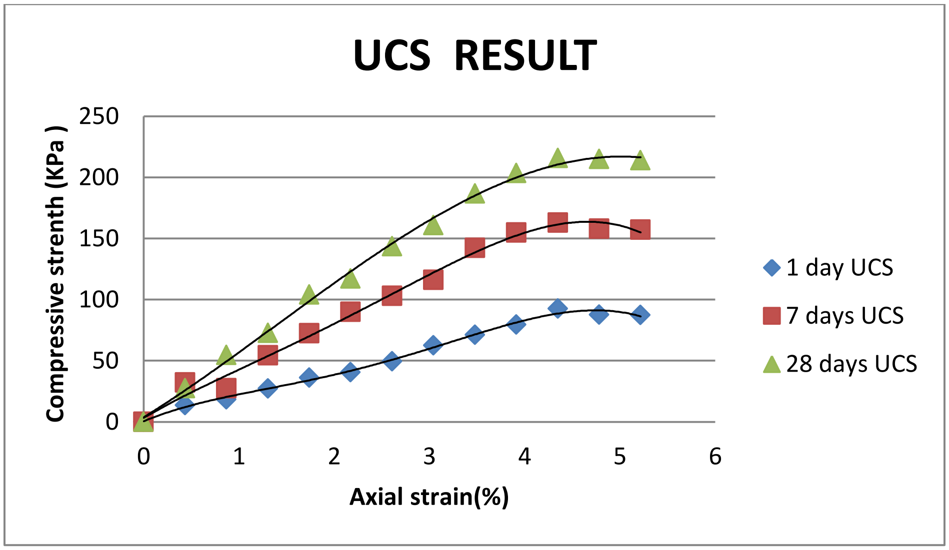

Fig 4.50 UCS curve of Black Cotton Soil+ 10% FA + 6%KSD

4.5.13. BCS+ 10% FA + 9% KSD

From the graph it has been observed that UCS of Black cotton soil was increased by 8.86 KPa for 1 day,30.84 KPa for 7 days and 48.86 KPa for 28 days by addition of 9% KSD and 10% FA.

UCS for 1 day = 88.15 KPa

UCS for 7 days=149.78 KPa

UCS for 28 days=184.18 KPa

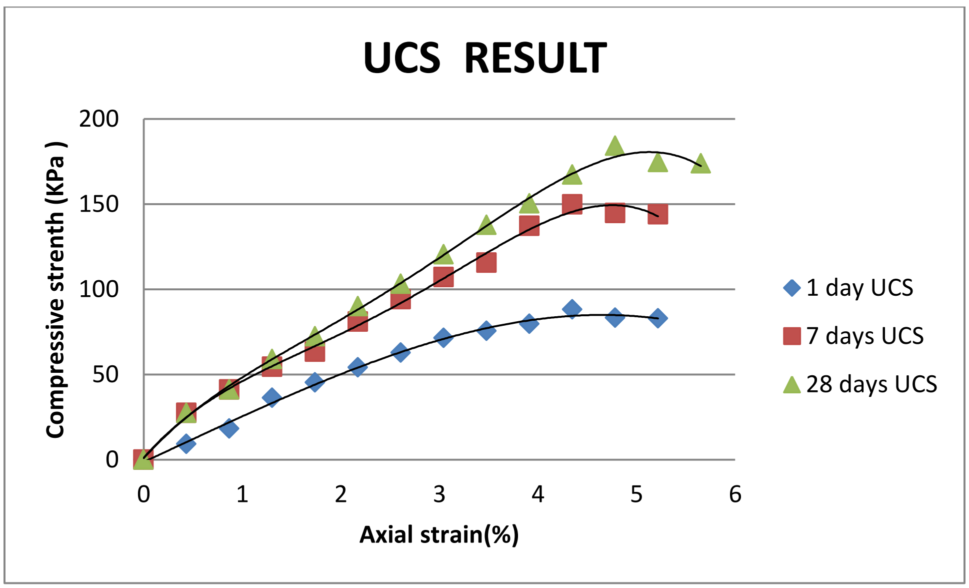

Fig 4.51 UCS curve of Black Cotton Soil+ 10% FA + 9%KSD

4.5.14. BCS+ 10% FA + 12% KSD

From the graph it has been observed that UCS of Black cotton soil was decreased by 3.38 KPa for 1 day, increased by 9.39 KPa for 7 days and 22.55 KPa for 28 days by addition of 12% KSD and 10% FA.

UCS for 1 day = 75.91 KPa

UCS for 7 days=128.33 KPa

UCS for 28 days=157.87 KPa

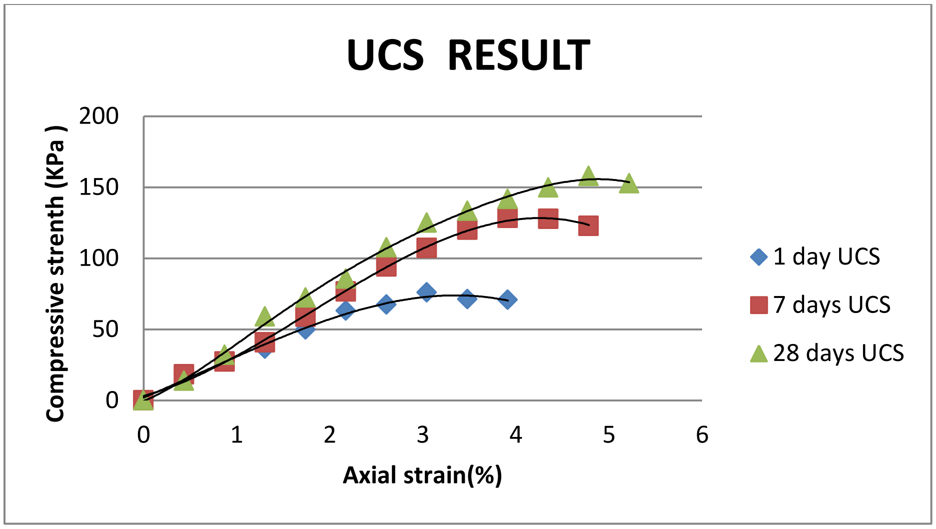

Fig 4.52 UCS curve of Black Cotton Soil+ 10% FA + 12%KSD

4.5.15. BCS+ 15% FA + 0% KSD

From the graph it has been observed that UCS of Black cotton soil was decreased by 12.61 KPa for 1 day, increased by 12.61 KPa for 7 days and 14.45 KPa for 28 days by addition of 0% KSD and 15% FA.

UCS for 1 day = 66.68 KPa

UCS for 7 days=131.55 KPa

UCS for 28 days=149.77 KPa

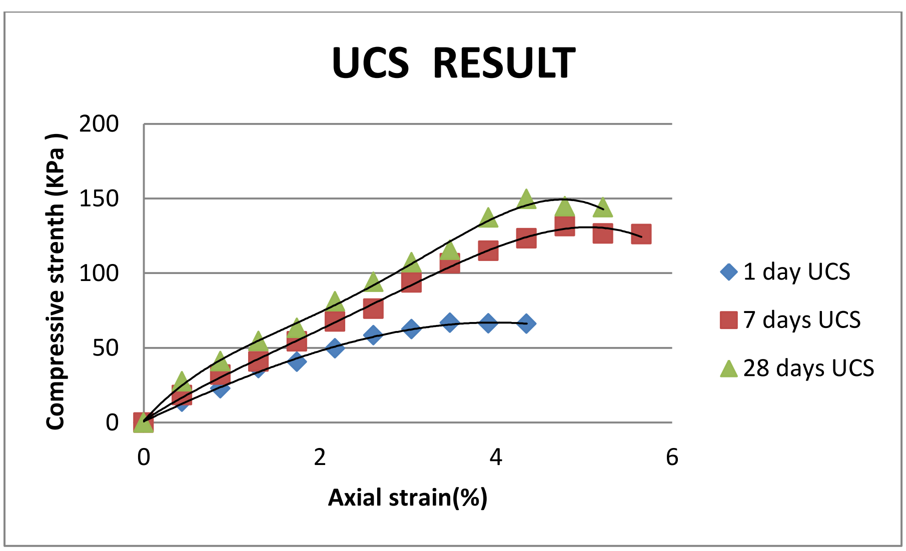

Fig 4.53 UCS curve of Black Cotton Soil+ 15% FA + 0%KSD

4.5.16. BCS+ 15% FA + 3% KSD

From the graph it has been observed that UCS of Black cotton soil was decreased by 7.84 KPa for 1 day, increased by 29.48 KPa for 7 days and 43.65 KPa for 28 days by addition of 3% KSD and 15% FA.

UCS for 1 day = 71.45 KPa

UCS for 7 days=148.42 KPa

UCS for 28 days=1178.97 KPa

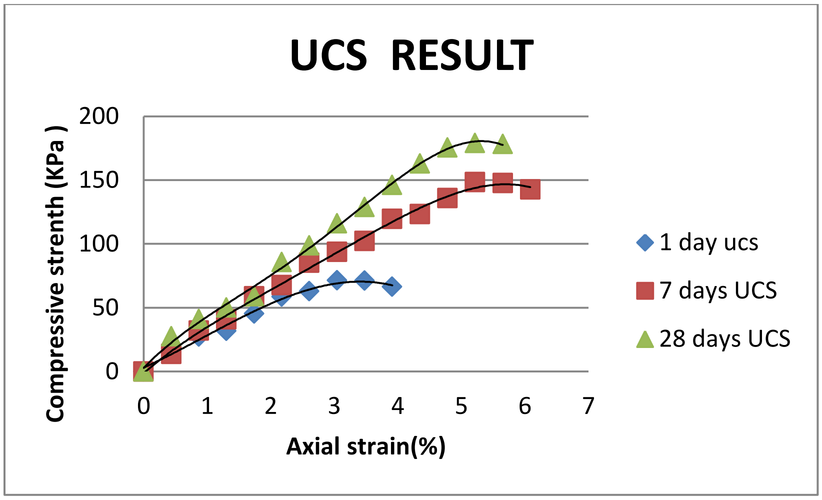

Fig 4.54 UCS curve of Black Cotton Soil+ 15% FA + 3%KSD

4.5.17. BCS+ 15% FA + 6% KSD

From the graph it has been observed that UCS of Black cotton soil was decreased by 3.38 KPa for 1 day, increased by 33.14 KPa for 7 days and 48.01 KPa for 28 days by addition of 6% KSD and 15% FA.

UCS for 1 day = 75.91 KPa

UCS for 7 days=152.08 KPa

UCS for 28 days=183.33 KPa

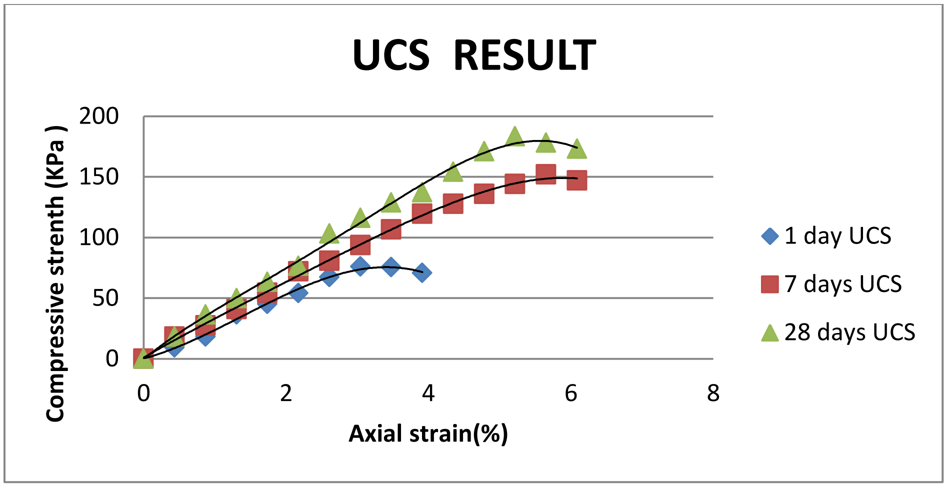

Fig 4.55 UCS curve of Black Cotton Soil+ 15% FA + 6%KSD

4.5.18. BCS+ 15% FA + 9% KSD

From the graph it has been observed that UCS of Black cotton soil was decreased by 7.53 KPa for 1 day, increased by 13.21 KPa for 7 days and 10.05 KPa for 28 days by addition of 9% KSD and 15% FA.

UCS for 1 day = 71.76 KPa

UCS for 7 days=132.15 KPa

UCS for 28 days=145.37 KPa

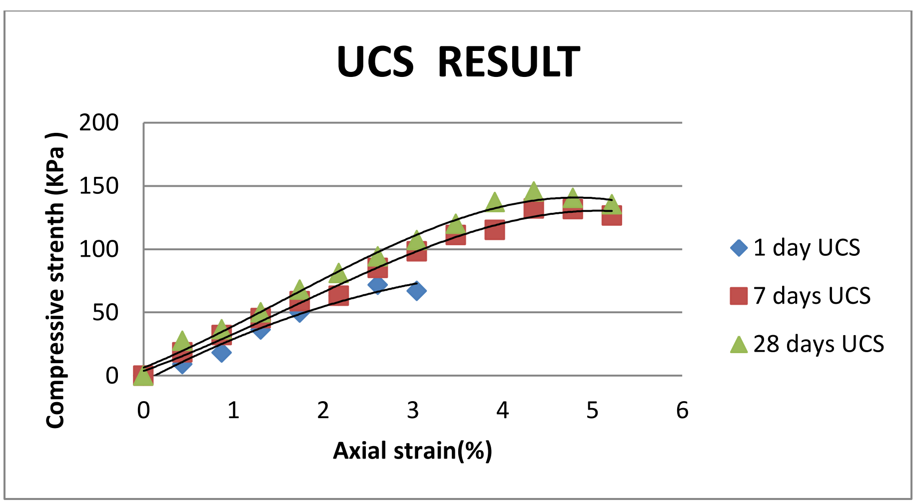

Fig 4.56 UCS curve of Black Cotton Soil+ 15% FA + 9%KSD

4.5.19. BCS+ 15% FA + 12% KSD

From the graph it has been observed that UCS of Black cotton soil was decreased by 16.23 KPa for 1 day, 2.85 KPa for 7 days and increased by 1.86 KPa for 28 days by addition of 12% KSD and 15% FA.

UCS for 1 day = 63.06 KPa

UCS for 7 days=116.09 KPa

UCS for 28 days=137.18 KPa

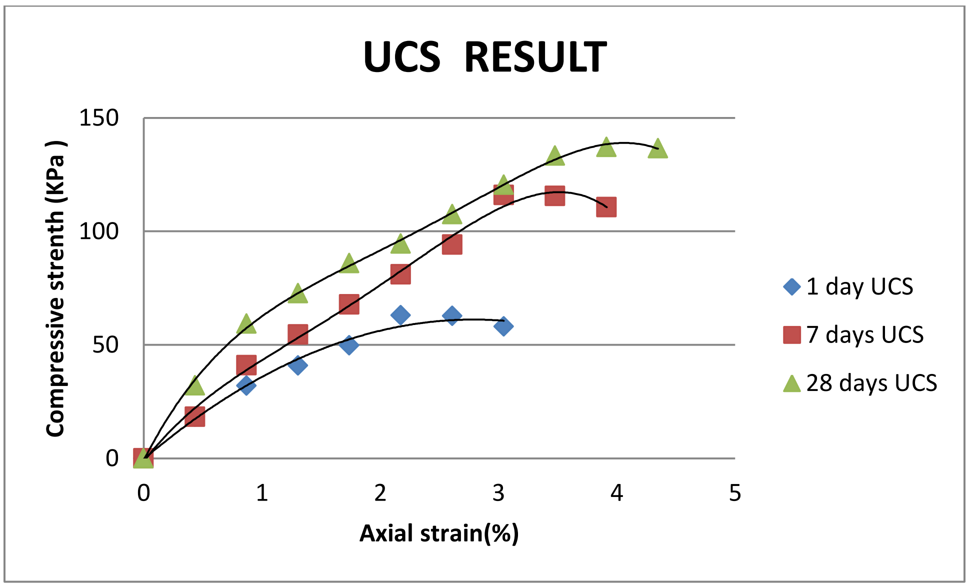

Fig 4.57 UCS curve of Black Cotton Soil+ 15% FA + 12%KSD

CHAPTER 5

ANALYSIS OF RESULTS

5.1.LIQUID LIMIT:

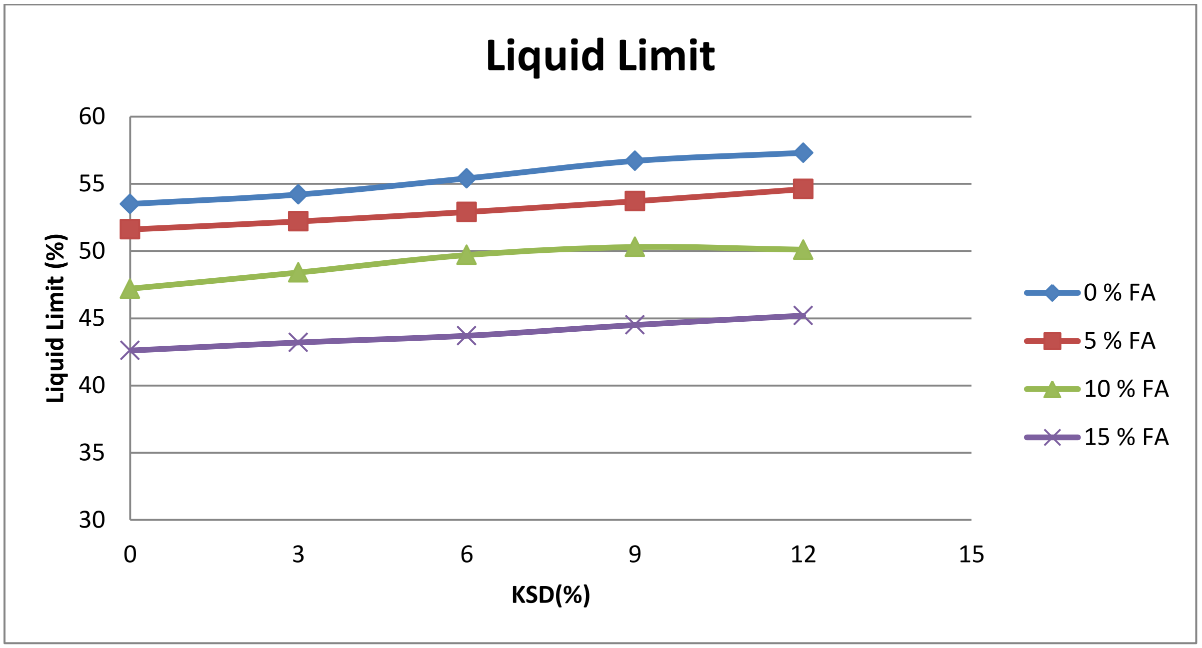

Fig 5.1 Variation of liquid limit with admixtures

Figure 5.1 shows variation in liquid limit of black cotton soil , such that when we add FA to BCS it reduces liquid limit while addition of Kota stone dust increases the liquid limit of soil. Reduction in liquid limit when we add fly ash is due to decrease in thickness of diffused double layer which in turn decrease in water holding capacity of soil. While when we add Kota stone increase in liquid limit takes place because soil-fly ash – KSD mix result in formation of more coarse aggregate with flocculated structure of particles, water entrapped in large void space of flocculated structure increase liquid limit.

5.2 PLASTIC LIMIT:

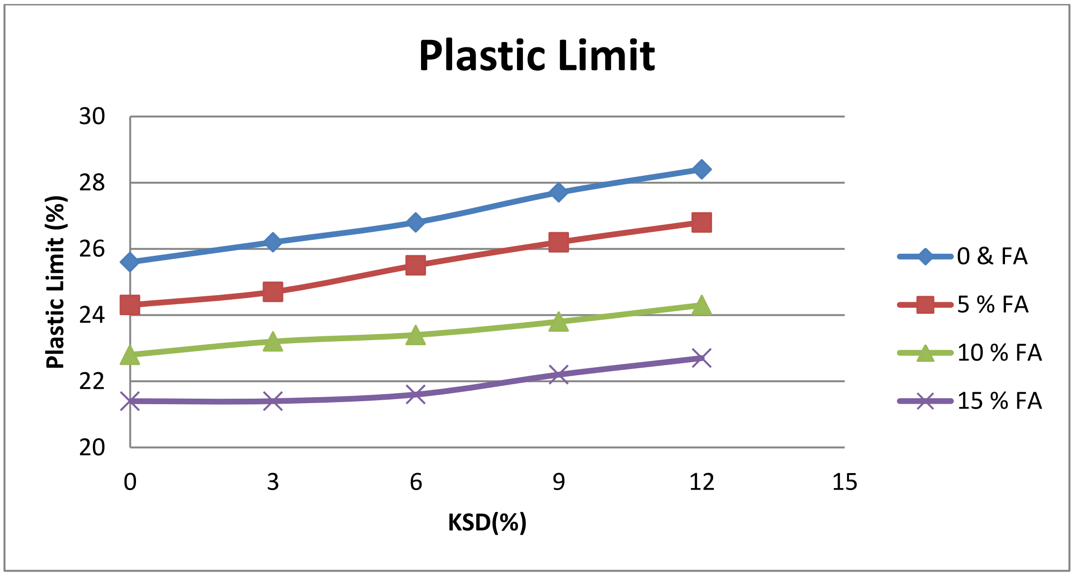

Fig 5.2 Variation of Plastic limit with admixtures

Figure 5.2 shows variation in plastic limit of black cotton soil , such that when we add FA to BCS it reduces plastic limit while addition of Kota stone dust increases the plastic limit of soil mix. As fly ash is non plastic in nature so when we add fly ash to the soil it decrease the value of plastic limit and when Kota stone dust is added then plastic limit increases because pozzolanic reaction takes place which result in formation of cementatious material which provide plasticity to the soil.

5.3 PLASTICITY INDEX:

Figure 5.3 shows variation in plasticity index of black cotton soil , such that when we add FA to BCS it reduces liquid limit while addition of Kota stone dust increases the plastic limit of soil mix. The plasticity index is a relative term which depends on the value of liquid limit and plastic limit. Reduction of plasticity index increase the workability of soil , as we know that those soil which have lesser plasticity index will be more stiff and more workable.

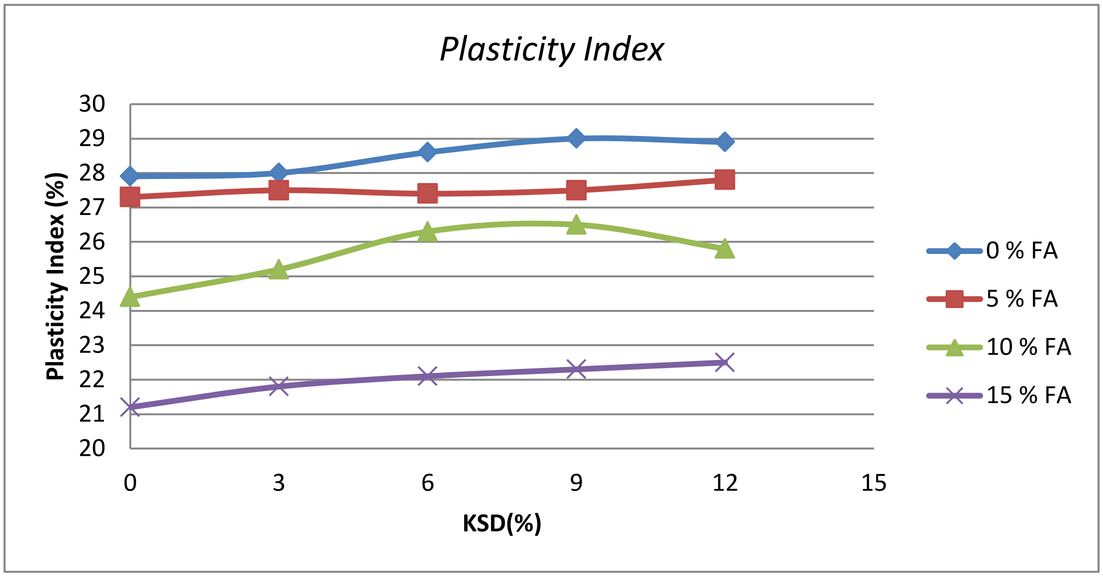

Fig 5.3 Variation of Plasticity Index with admixtures

5.4 STANDARD PROCTOR TEST:

Figure 5.4 shows variation in OMC of black cotton soil , such that when we add FA to BCS it increases OMC , similarly addition of Kota stone dust increases the OMC of soil mix. Soil have up to 5 % of void ratio whereas fly ash has up to 15 % void ratio at maximum dry density , more void ratio result in built up of more pore pressure during proctor test thus it have a large range of water content over compaction.

Figure 5.5 shows variation in MDD of black cotton soil , such that when we add FA to BCS it decreases MDD , similarly addition of Kota stone dust decreases the MDD of soil mix. The reduction of the MDD of soil mix with the rise of the percentage of fly ash is due to the lesser specific gravity of the fly ash relative to the black cotton soil and when we add Kota stone dust again reduction takes place because formation of cementatious compounds due to pozzolanic reaction and these compounds have lesser density relative to black cotton soil.

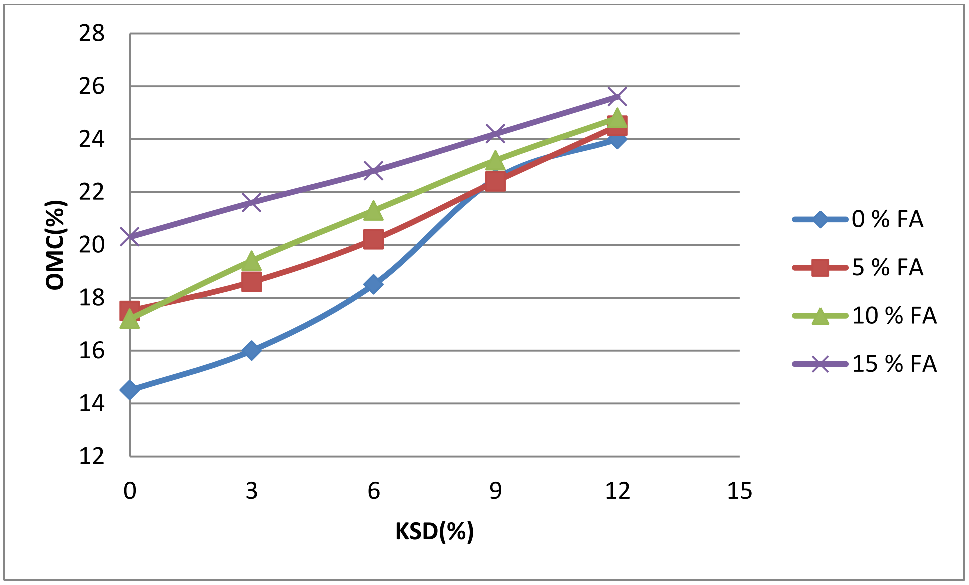

Fig 5.4 Variation of OMC with admixtures

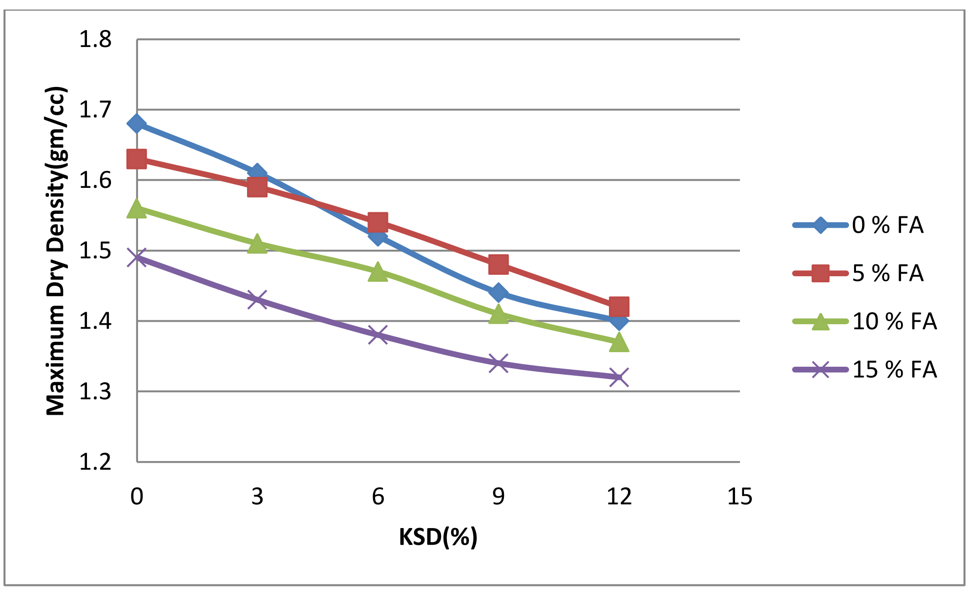

Fig 5.5 Variation of MDD with admixtures

5.5 FREE SWELL INDEX:

Figure 5.6 shows variation in FSI of black cotton soil , such that when we add FA to BCS it decreases FSI for 5 and 10% for 15% FSI increases its value , similarly addition of Kota stone dust decreases the FSI upto 6% after that it increases FSI value of soil mix,so optimum dose for FSI is % FA with % KSD.

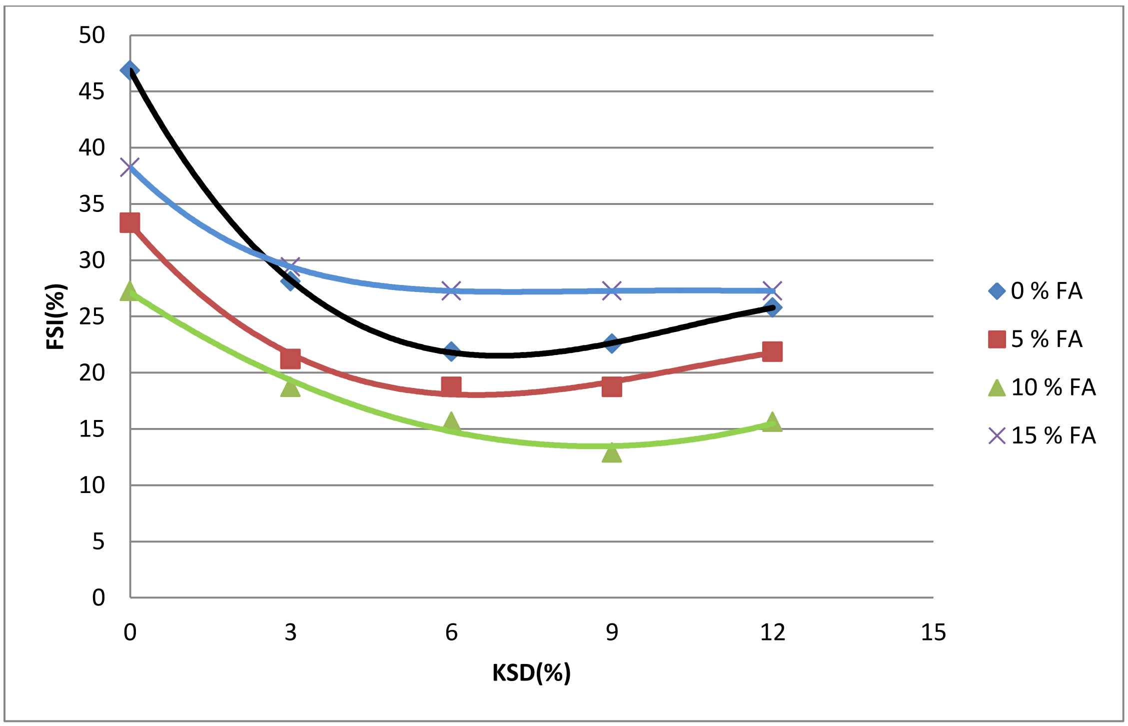

Fig 5.6 Variation of FSI with admixtures

5.6 UCS RESULT :

Figure 5.7 shows variation of UCS of 1 day of black cotton soil , such that when we add FA to BCS it increases UCS upto 10 % and for 15% FA addition it decreases UCS , similarly addition of Kota stone dust increases UCS value upto 6 % and after this reduction in values takes place so optimum dose is 10FA with 6% KSD.

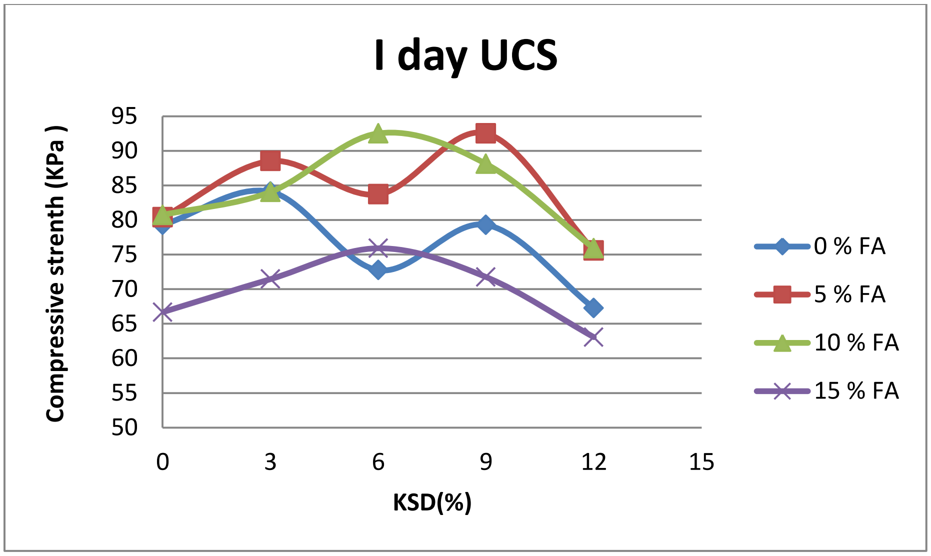

Fig 5.7 Variation of UCS of 1 day with admixtures

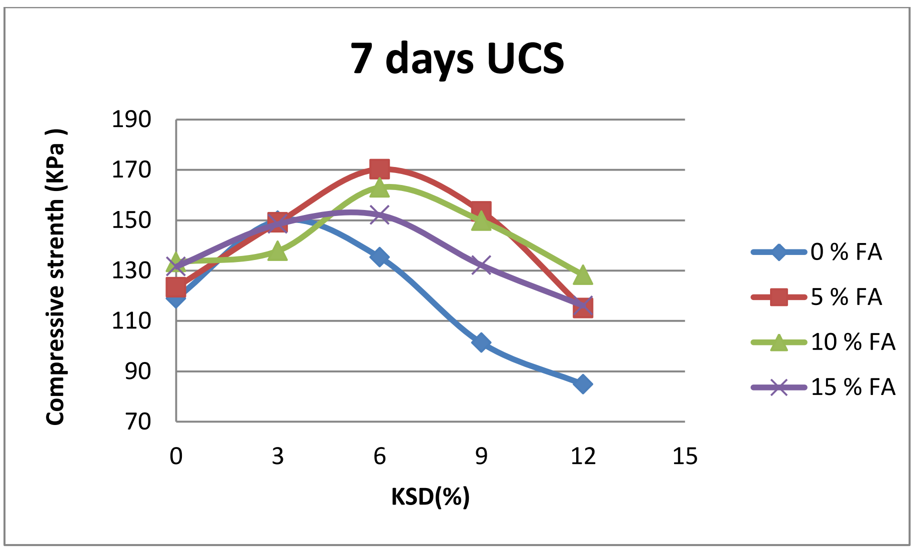

Fig 5.8 Variation of UCS of 7 day with admixtures

Figure 5.8 shows variation of UCS of 7 day of black cotton soil , such that when we add FA to BCS it increases UCS upto 5 % and for 10 and 15% FA addition it decreases UCS , similarly addition of Kota stone dust increases UCS value upto 6 % with FA and after this reduction in values takes place. If we use KSD without FA than for 3% value of UCS increases and further addition reduces UCS value so optimum dose is 5% FA with 6% KSD.

Figure 5.9 shows variation of UCS of 28 day of black cotton soil , such that when we add FA to BCS it increases UCS for 10 % and for 0 and 5% FA addition it decreases at some point and increases some where,for 15 % FA decreases UCS value, similarly addition of Kota stone dust increases UCS value up to 6 % with FA and after this reduction in values takes place. So optimum dose is 10% FA with 6% KSD.

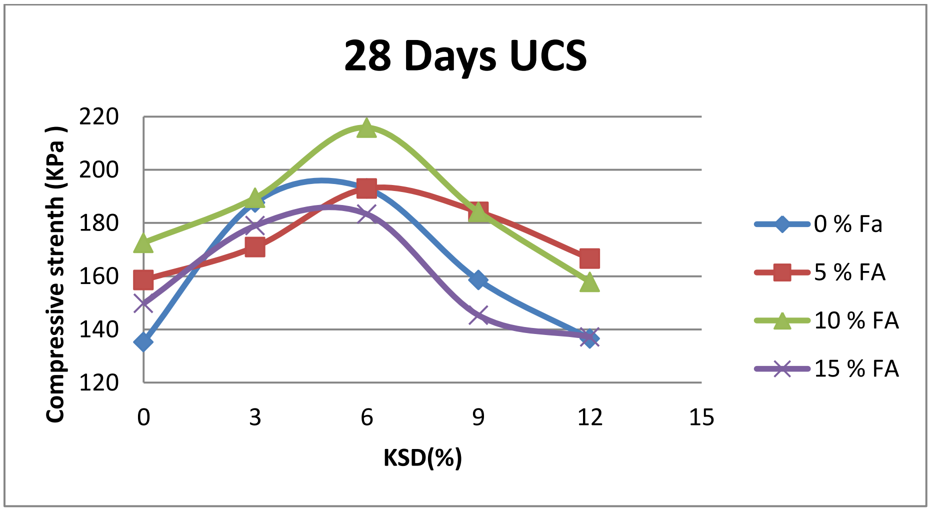

Fig 5.9 Variation of UCS of 28 day with admixtures

From the above graph for UCS is clear that at beyond optimum quantity of fly ash when we add more amount of fly ash creates unbounded silt particles which don't have friction and cohesion so causes decrease in strength, up to optimum fly ash and Kota stone dust induce pozzolanic reactions which makes cementatious material, these material contribute to shear strength of soil and its mix.