IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Stabilisation Of Black Cotton Soil Using Reckon Fibre

Ramkishan Yadav' Er. Jaspreet

M-tech research scholar, Department of civil engineering, CT University, Ferozepur Road, Ludhiana.
Assistant Professor, Department of civil engineering, CT University, Ferozepur Road Ludhiana.

Abstract:

The main objective of this study is to investigate the effect of RECRON fibers in BLACK COTTON soil. Civil engineers face various problems while designing the foundations on highly compressible Black Cotton soil due to poor bearing capacity and excessive settlement when it comes in affinity of water. Most of the soil especially Black Cotton soil available in our surroundings is such that it has good compressive strength, adequate shear strength but is weak in tension or has poor tensile strength. To overcome the same, many researchers have concentrated their studies on soil improvement techniques by developing new such materials or a combination of such materials.

In this study of Black Cotton soil along with Recron fibres is used. The Recron fibres of different aspect length (6mm, 12mm and 18mm) is mixed properly with soil mixture in varying percentages (0.50%, 0.75% and 1.0%) by dry weight of Black Cotton Soil. The main objective is to study the index and engineering properties like California Bearing Ration (CBR), Shear strength parameter (c & ϕ), Atterberg's limits at all above mentioned percentages. The test results would indicate improved geotechnical properties of Black Cotton Soil.

The optimized results are obtained on using 0.75% of 6 mm length Recron fibre as its use improved geotechnical properties like shrinkage limit by 1.88 times when compared with normal Black Cotton soil. California bearing ratio increased 2.67 times, Liquid limit decreased by 0.94 times, cohesion value increased by 4 times, moreover free swell index decreased by 0.42 times when compared with the normal Black Cotton soil in which no Recron fibre was used.

Keywords: Recron fibre, Black Cotton Soil, CBR

Introduction:

Black cotton soils are found in extensive region of Deccan Trap in India. The rate of montmorillonite is more in Black Cotton soil which causes expansiveness and crack occurs in soil without any warning which is dangerous for construction. Here, in this project, soil stabilization has been done with the help of Recron fibres.

Black Cotton Soil is problematic in construction mainly because of its high swelling and shrinkage properties. It is very hard when dry, but loses stability completely when wet. On drying it splits into cracks of about 15cm width and about 3m depth. High swelling and shrinkage characteristics during drying and wetting processes resulting in vertical and horizontal movement of soil mass and low bearing capacity (when wet). Black cotton soils are highly plastic and compressible, when they are saturated. Because of the undesirable properties the Black cotton soils are generally regarded unsuitable for engineering constructions hence to improve the properties of these soils for foundation and constructions, the stabilization is generally resorted to.

Soil stabilization is the process of altering some soil properties by different methods, mechanical or chemical in order to produce an improved soil material which has all the desired engineering properties. Recron fibres are made by polymerization of pure terephthalic acid and Mono ethylene glycol using catalyst. Recron fibres are capable of increasing the California Bearing Ratio value and reducing cracks developed in Black Cotton soil due to swelling and shrinkage. In this paper we would be showing effect of different percentages of Recron fibre content in Black Cotton soil.

Objectives:

The Aim of using Recron fiber for the stabilization of Black Cotton Soil is to enhance the geotechnical properties of the soil, thereby making it more suitable for construction purposes. This includes:

- **Improving Strength**: To increase the unconfined compressive strength (UCS) and California Bearing Ratio (CBR) of Black Cotton Soil by incorporating Recron fibers.
- **Reducing Swell-Shrink Tendency**: To mitigate the swell-shrink behavior of Black Cotton Soil, which is critical for maintaining the structural integrity of pavements, embankments, and other constructions.
- **Enhancing Load-Bearing Capacity**: To improve the load-bearing capacity of the soil, ensuring it can support low-rise structures and infrastructure projects effectively.
- **Optimizing Fiber Content and Aspect Ratio**: To determine the optimal content and aspect ratio of Recron fibers that yield the best improvement in soil properties.
- **Assessing Durability**: To evaluate the long-term durability and performance of Recron fiber-reinforced Black Cotton Soil under various environmental conditions.
- **Promoting Practical and Economical Solutions**: To develop a practical and cost-effective soil stabilization method that leverages locally available materials and advanced reinforcing techniques.

By achieving these objectives, the study aims to provide a comprehensive understanding of how Recron fibers can be effectively utilized to stabilize Black Cotton Soil for diverse engineering applications.

(I) Literature Review

Black Cotton soil stabilization has commenced with the use of industrial wastes like fly ash, lime sludge, iron ore tailings, cement kiln dust etc. Moreover some researchers are done using fibres. Various research papers are presented below in this regard:

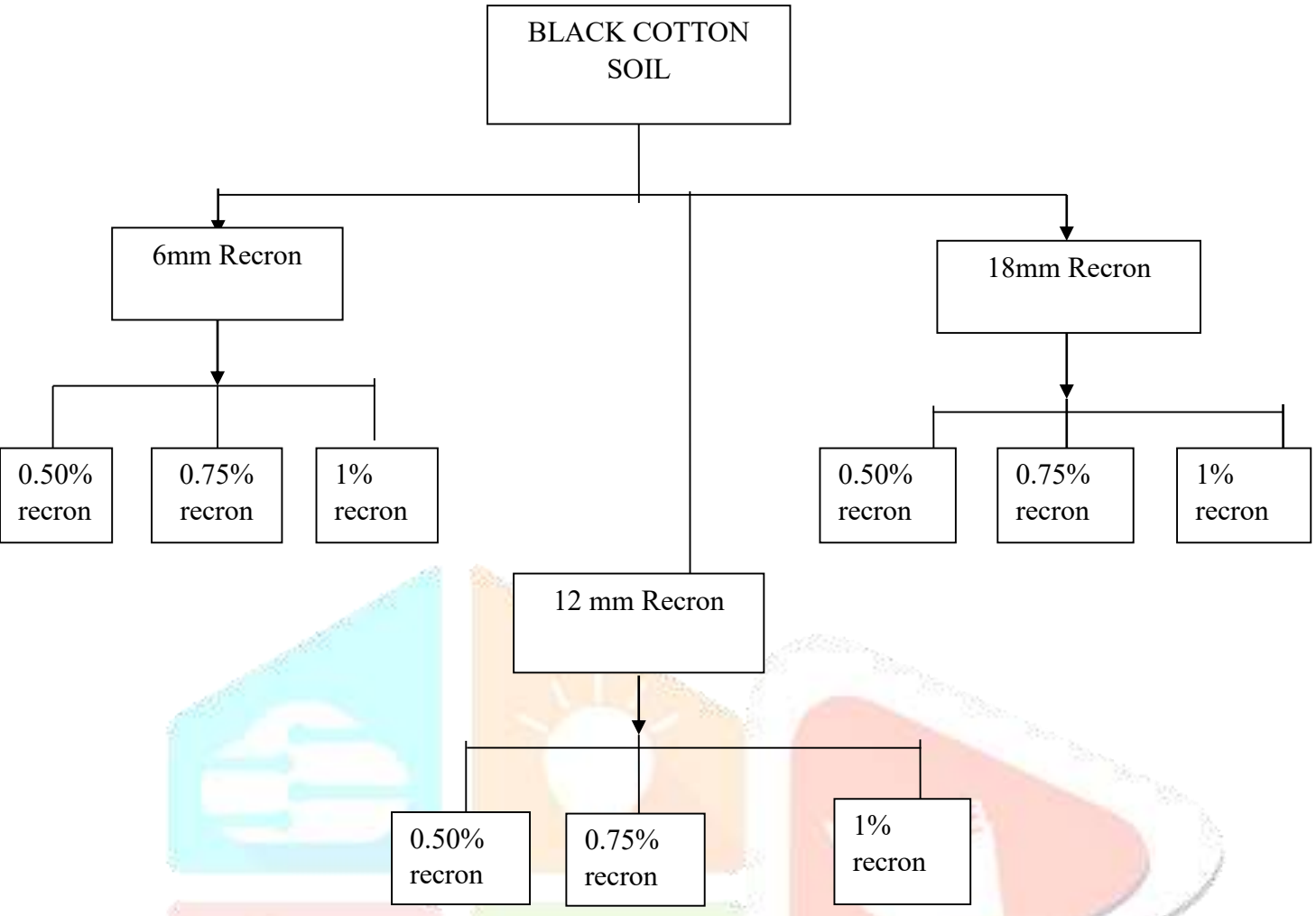
1. Black Cotton Soil Stabilization Using Industrial Wastes:
   Researchers have explored various practical and economical soil stabilization methods, focusing on expansive soils like Black Cotton Soil. Amarjit Singh (1967) reported using fly ash and lime for road construction, while Amos and Wright (1972) studied fly ash's effect on Black Cotton Soil. Yudhbir and Honjo (1991) and Bell (1993) noted the advantages of pozzolanic fly ashes. Sivapullaia (1996) found fly ash reduced the liquid limit. Cokca (2001) recommended fly ash as a stabilizing agent. Pandian (2002) and Phanikumar and Sharma (2004) highlighted improvements in CBR and soil properties. Jian-Long Zheng, Rui Zhang and He-Ping Yang (2009) stabilized soil using lime and cement. Supritha D K, J Ranjith, Kavya U S, Puneeth B (2016) used iron ore tailings to enhance soil strength. P. V. Koteswara Rao, K. Satish Kumar & T. Blessingstone (2012) found polymer fibres and cement kiln dust significantly improved soil properties.
2. Black Cotton Soil Stabilization Using Fibres:

Researchers have explored various methods for stabilizing expansive soils like Black Cotton soil. Prof. R. K. Sharma (2012) studied soil mixed with fly ash and Recron fibres, finding improvements in moisture-density and CBR with 30% fly ash and 0.5-1.5% fibre. Sunila Kumar Biradar, Shivaraj Biradar, A.D Kotagond (2014) showed stabilization using lime and Recron fibres, altering geotechnical properties for better load-bearing capacity. H. S. Chore (2011) used a regression model to predict compressive strength in fibre-reinforced fly-ash concrete. Ashish Kumar Dash (2011) achieved optimal strength in concrete with Recron fibre and silica fume. Muhammad Nawazish Husain, Praveen Aggarwal (2015) found Recron fibres improved the CBR and UCS of silty soil. Gopal Ranjan, R. M. Vasan and H. D. Charan (1996) highlighted the role of aspect ratio in increasing soil shear strength. Despite extensive research, no studies have varied Recron fibre aspect ratios in Black Cotton Soil stabilization.

(II) Proposed Methodology

In this study, we have to proceed by performing the following tests on Black Cotton for identifying its properties:

1. Grain size distribution
2. Atterberg's limit
   - Plastic limit
   - Shrinkage limit
   - Liquid limit
3. Specific gravity
4. Modified Proctor
   - Optimum moisture content
   - Maximum dry density
5. CBR(soaked)
6. Triaxial
7. Free swell index



EXPERIMENTAL RESULTS

It has been mentioned above the geotechnical properties which will be tested during this project and below are the results and graphs obtained when various tests are conducted on the soil with or without varying percentages and aspect ratios of Recron fibre.

S.No	Experiments	Results
1	Coefficient of Curvature	1.56
2	Coefficient of Uniformity	14.55
3	Shrinkage Limit	13.88%
4	Liquid Limit	63%
5	Plastic Limit	32.32%
6	Optimum Moisture Content	23.20%
7	Max Dry Density	1.62 g/cc

8	Specific Gravity	2.7
9	California Bearing Ration (Soaked)	0.95%
10	Triaxial	
	Cohesion	1.1
	Angle of shearing Resistance	22°
11	Free swell Index	70 %

Table 5.1: Virgin Black Cotton soil

1. **Particle size distribution:**

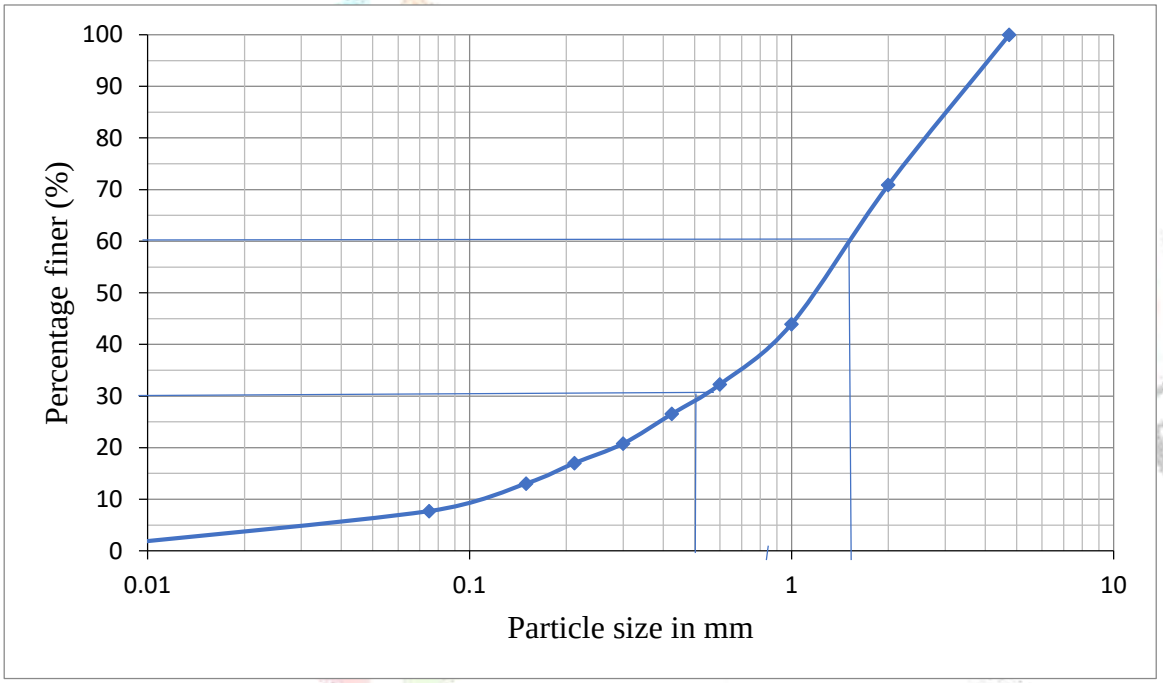


Fig 5.1 – Particle size distribution of Black Cotton Soil

Coefficient of Curvature (C_c) for Black Cotton soil is found to be 1.56 and the Coefficient of Uniformity (C_u) is found to be 14.55 which signify that the soil is well graded soil and each and every type of soil particle is available in the lot.

2. **Liquid Limit**

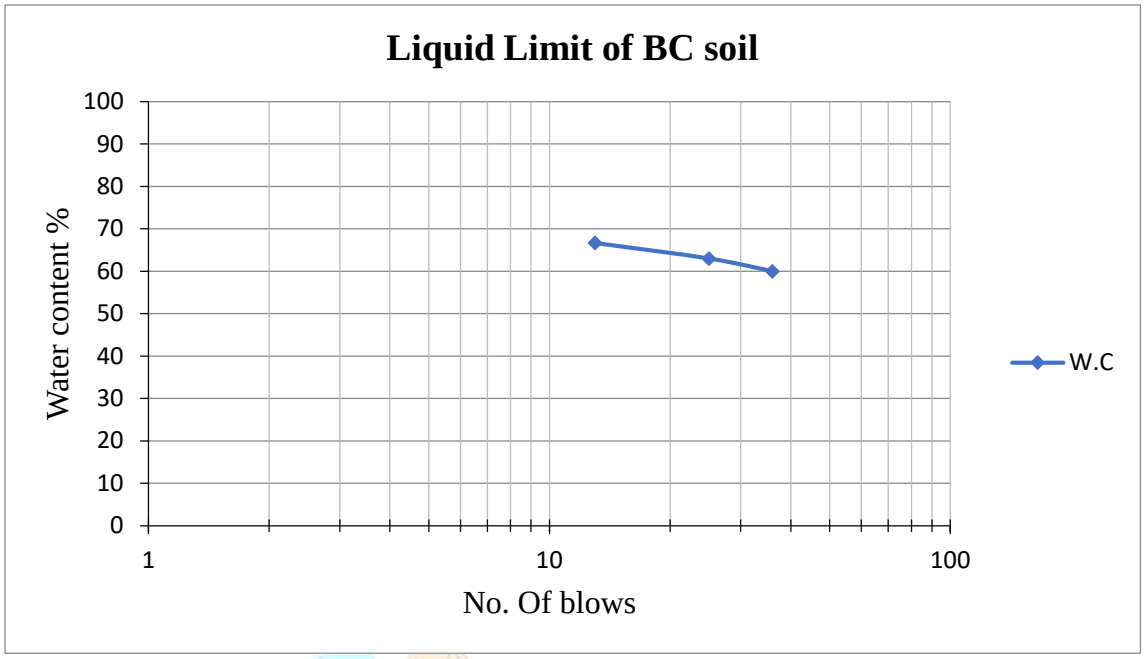


Fig 5.2: Liquid limit of Black Cotton soil

Liquid Limit = 63% and as the definition says it is the maximum water content after which soil loses its plasticity and starts behaving like a liquid and this value comes in the range of liquid limit for Black Cotton soil which is 60-100%

3. **Modified proctor:**

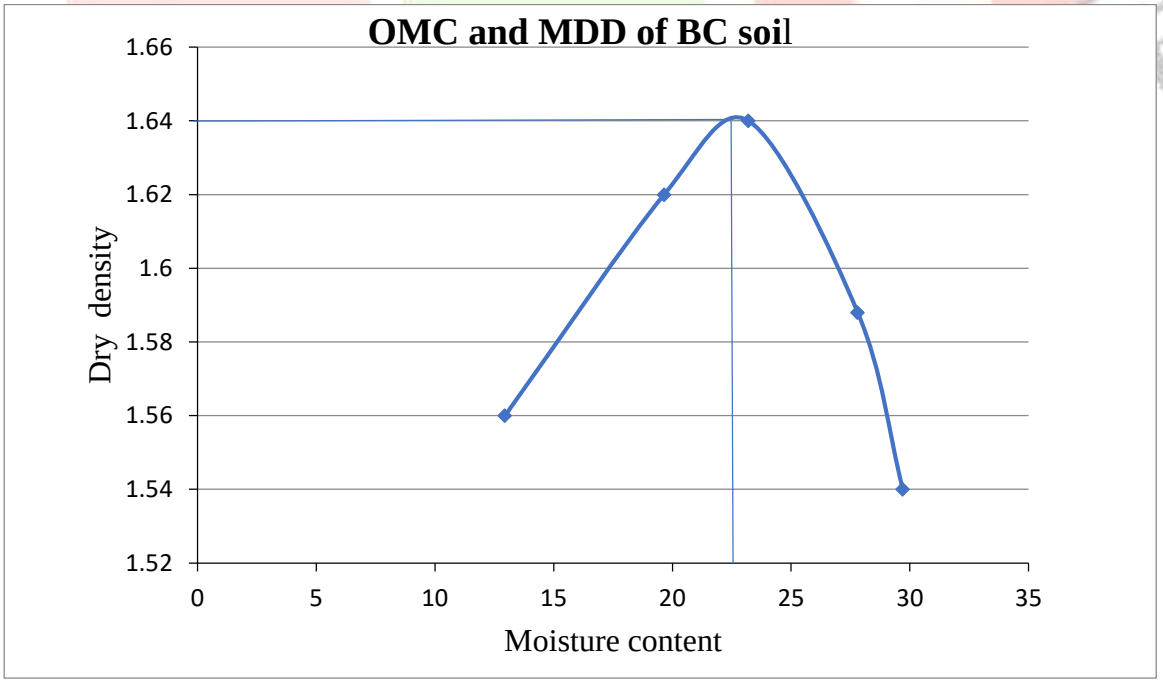


Fig 5.3 – OMC & MDD of Black Cotton Soil

Optimum Moisture Content = 23.20%

Maximum Dry Density =1.62 g/cc

These values give the measure of the compactness or how well a soil can be compacted for achieving better strength, more the dry density lesser is the moisture content and higher is the compactness

4. California Bearing Ratio

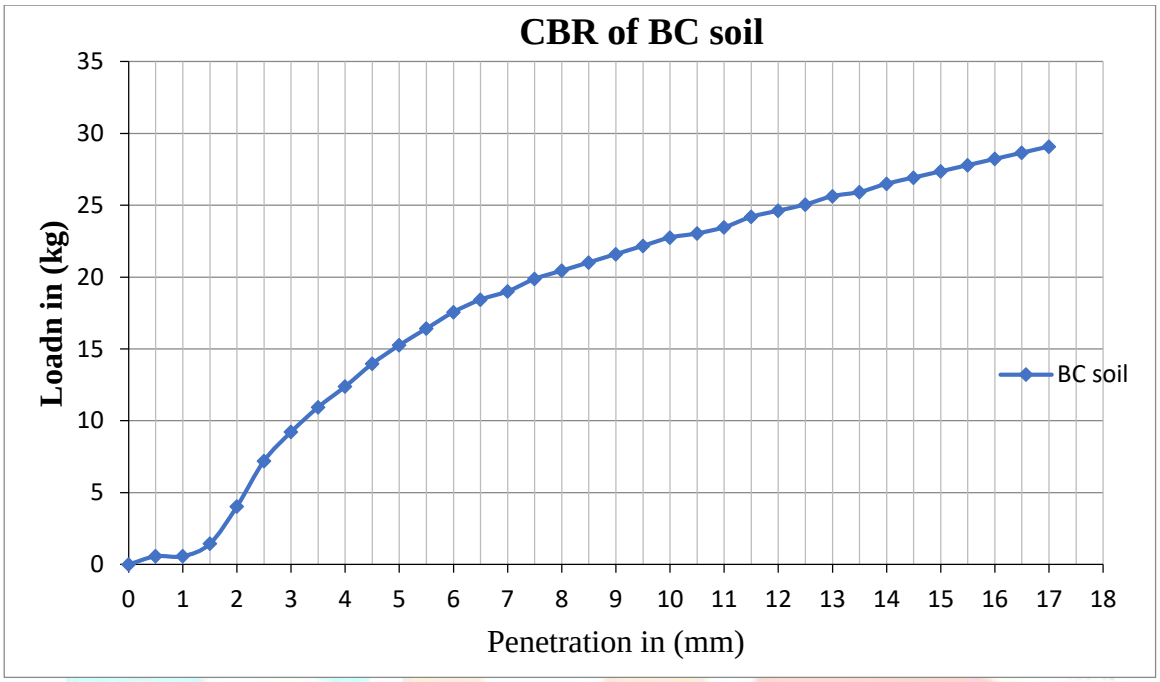


Fig 5.4: CBR of Black Cotton Soil

California Bearing Ratio is the measure of resistance to penetration and in this project it is found to be 0.95% which is unsatisfactory and thus stabilization is done by reinforcing the soil using Recron fibres

When Black Cotton soil was tested by adding 0.5% recron fibre of 6mm length geotechnical properties which include shrinkage limit improved by 13.83% ,liquid limit decreased by 3.27%, California bearing ratio increased by 70.5% , moreover the cohesion values observed were 4 times the value of cohesion for Black Cotton soil without using recron fibres ,also the free swell index of Black Cotton soil was reduced by half i.e., by 50%. The results obtained by addition of recron fibres are shown in the table below along with the graphs of relevant data:

S.No	Experiments	Results
1	Shrinkage Limit	15.80%
2	Liquid Limit	61%
3	California Bearing Ration (Soaked)	1.62%
4	Cohesion	4
5	Angle of shearing Resistance	10°
6	Free swell Index	35%

Table 5.2: Results obtained on the combination of BCS + 0.5% R + 6L

1. **Liquid Limit**

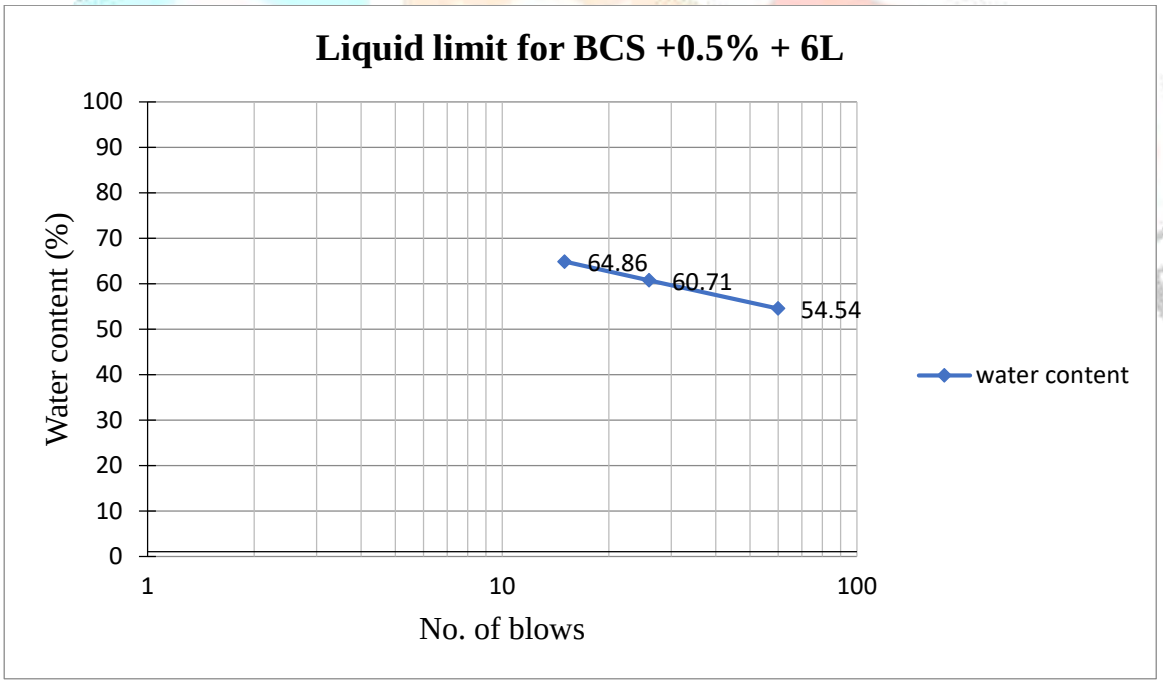


Fig5.5: Liquid limit for BCS +0.5% + 6L

2. **California bearing ratio**

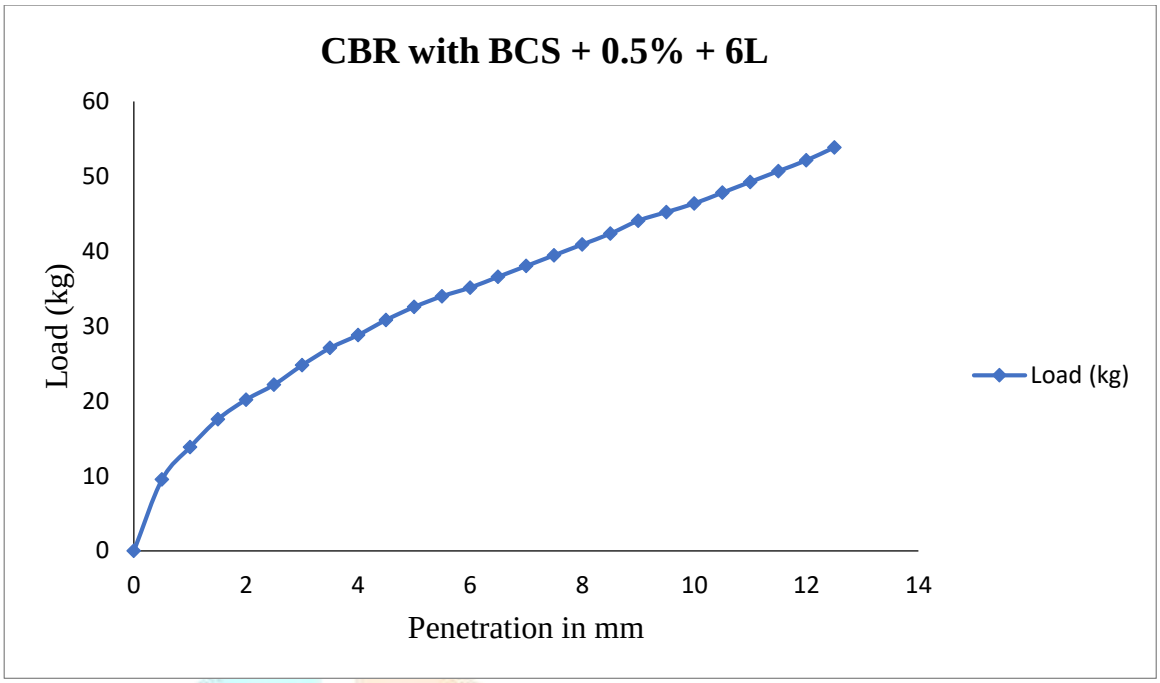


Fig. 5.6 – CBR with BCS + 0.5% + 6L

When Black Cotton soil is tested with 0.5% recron fibres of 12mm length geotechnical properties which include shrinkage limit is increased by 5.90%, liquid limit decreased by 1.58% , California bearing ratio value is increased by almost 0.7 times, moreover the cohesion value is increased by 3.5 times. The results are shown in the table below along with the graphs:

S.No	Experiments	Results
1	Shrinkage Limit	14.70%
2	Liquid Limit	62%
3	California Bearing Ration (Soaked)	1.77%
4	Cohesion	3.5
5	Angle of shearing Resistance	10°
6	Free swell Index	30%

Table 5.3: Results obtained on combination of BCS + 0.5%R + 12L

1. **Liquid Limit**

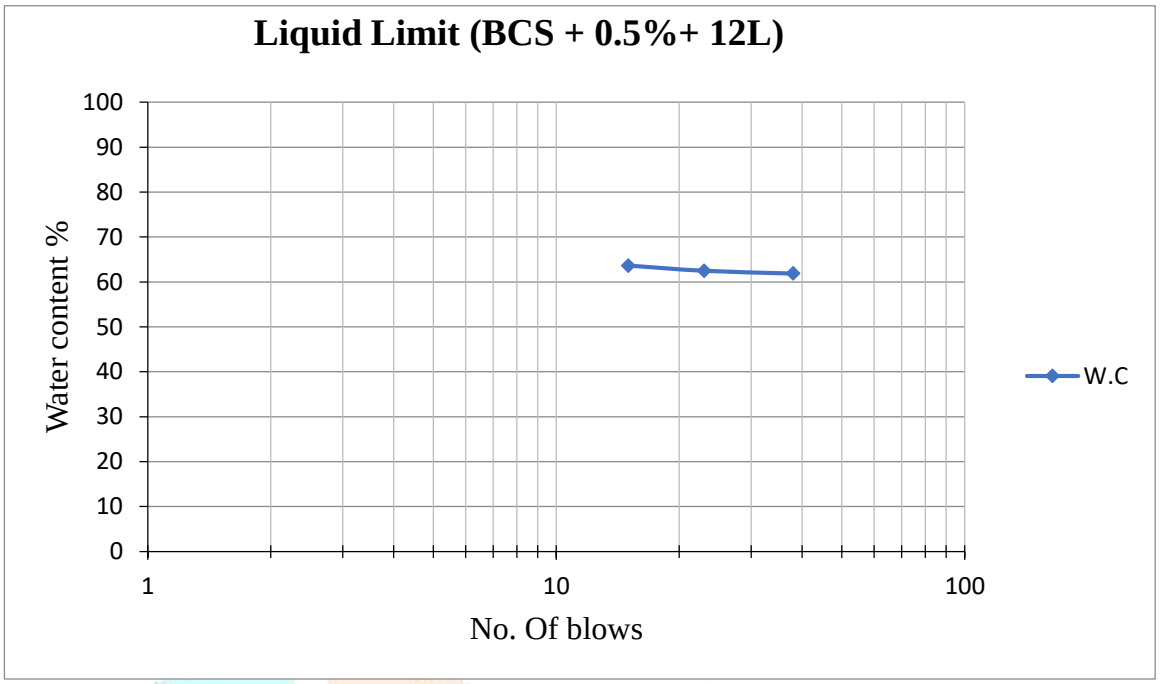


Fig. 5.7 – Liquid Limit (BCS + 0.5% + 12L)

2. **California bearing ratio**

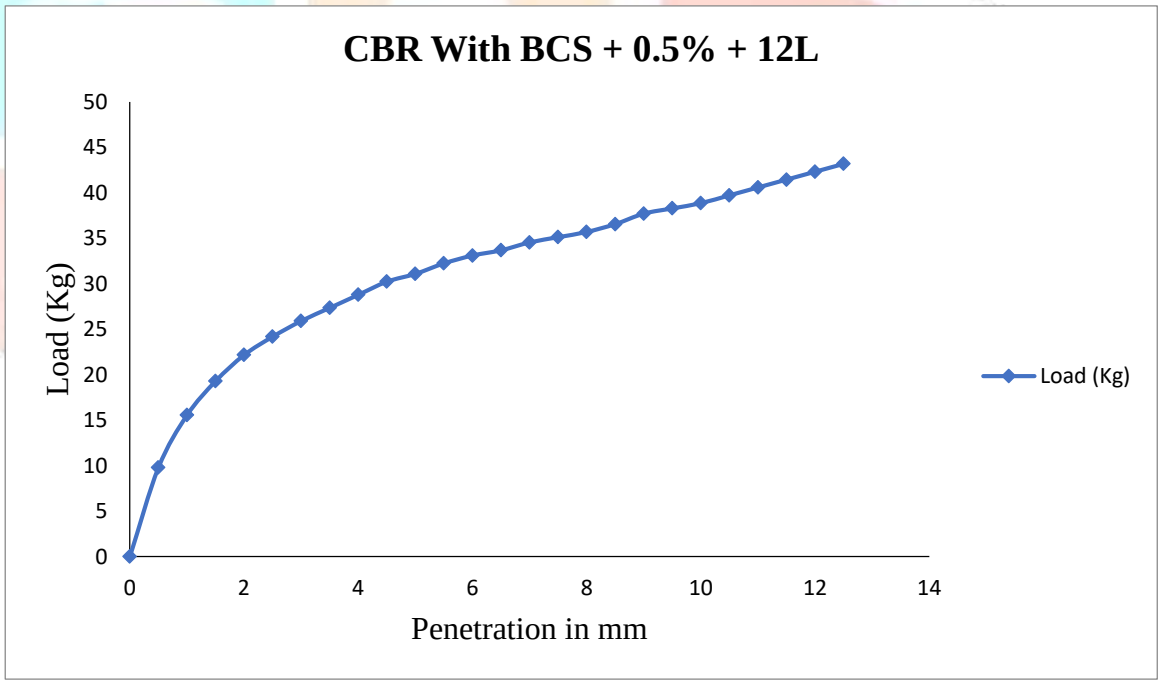


Fig 5.8: CBR of BCS + 0.5% +12L

When Black Cotton soil is tested with 0.5% recron fibres of 18 mm length geotechnical properties which include shrinkage limit is increased by 42.29%, California bearing ratio value is increased by almost 2.4 times, moreover the cohesion value is increased by 2.2 times. The results are shown in the table below along with the graphs:

S.No	Experiments	Results
1	Shrinkage Limit	19.75%
2	California Bearing Ration (Soaked)	2.43%
3	Cohesion	2.2
4	Angle of shearing Resistance	19°
5	Free swell Index	40%

Table 5.4: Results obtained on combination of BCS + 0.5%R +18L

1. **California Bearing Ratio**

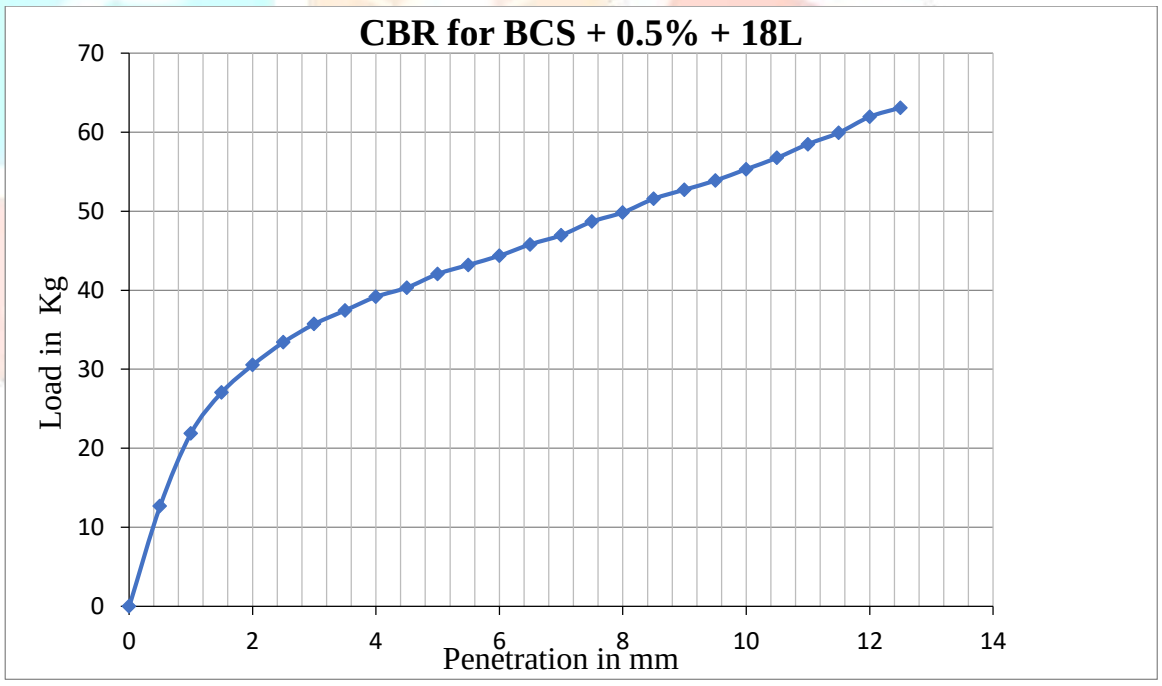


Fig 5.9: CBR for BCS + 0.5% + 18 L

When Black Cotton soil is tested with 0.75% recron fibres of 6 mm length geotechnical properties which include shrinkage limit is increased by 70.19%, California bearing ratio value is increased by almost 2.5 times, moreover the cohesion value is increased by 4 times, moreover the free swell index is decreased by 57.14 %. The results are shown in the table below along with the graphs:

S.No	Experiments	Results
1	Shrinkage Limit	23.62%
2	Liquid Limit	59%
3	California Bearing Ration (Soaked)	2.54%
4	Cohesion	4
5	Angle of shearing Resistance	8°
6	Free swell Index	30%

Table 5.5: Results obtained on combination of BCS + 0.75%R + 6

1. **Liquid Limit**

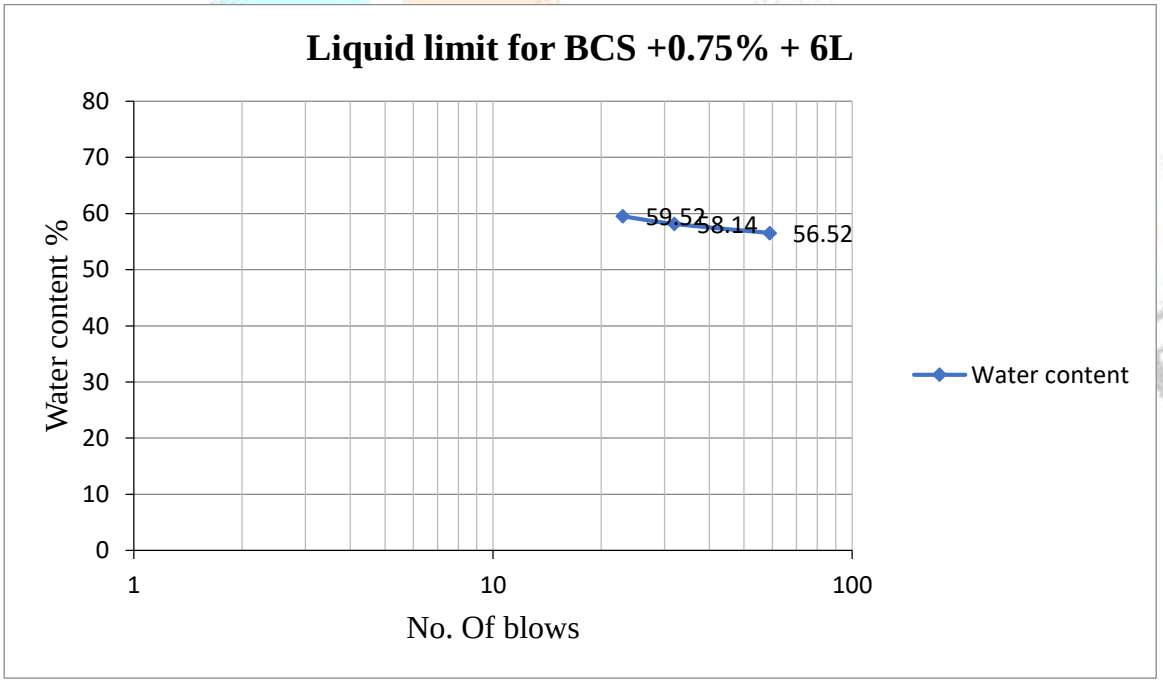


FIG: 5.10 – Liquid Limit BCS +0.75% +6L

2. **California bearing ratio**

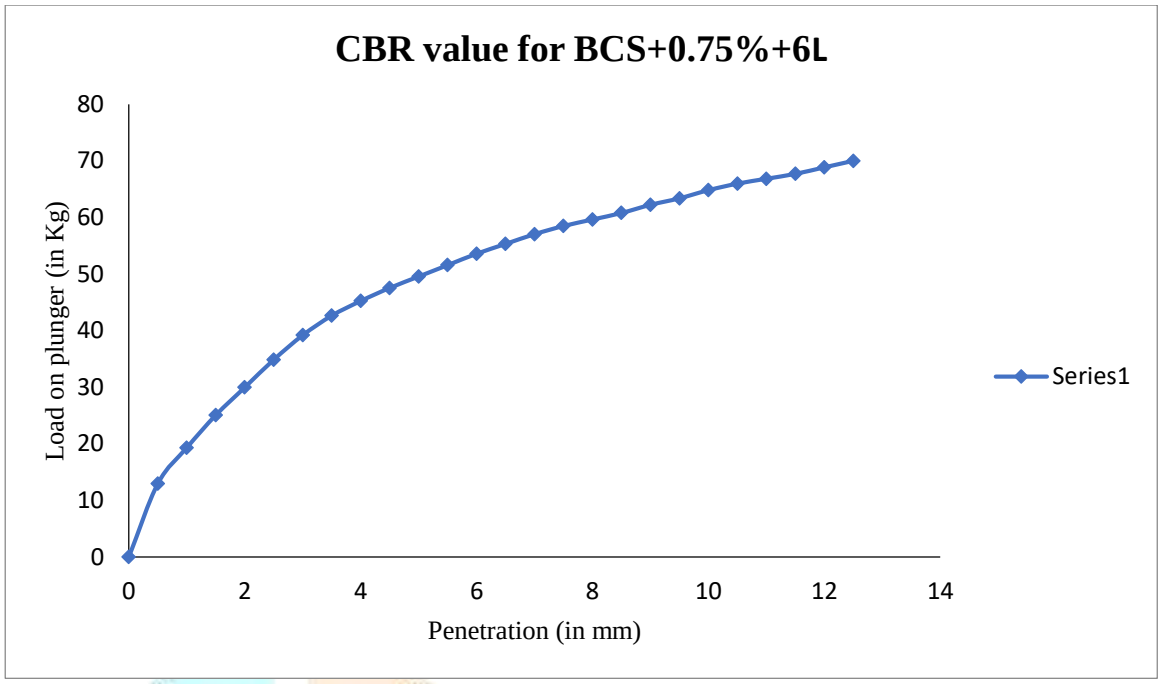


Fig 5.11: CBR value for BCS +0.75% +6L

When Black Cotton soil is tested with 1% recron fibres of 18 mm length geotechnical properties which include shrinkage limit is increased by 60%,liquid limit is decreased by 3.65%, California bearing ratio value is increased by almost 2 times, moreover the cohesion value is increased by 3.3 times also the free swell index is decreased by 42.85%. The results are shown in the table below along with the graphs:

S.No	Experiments	Results
1	Shrinkage Limit	22.22%
2	Liquid Limit	60.70%
3	California Bearing Ration (Soaked)	2.05%
4	Cohesion	3.3
5	Angle of shearing Resistance	10°
6	Free swell Index	40%

Table 5.6: Results obtained on combination of BCS+ 1% R + 6L

1. **Liquid Limit**

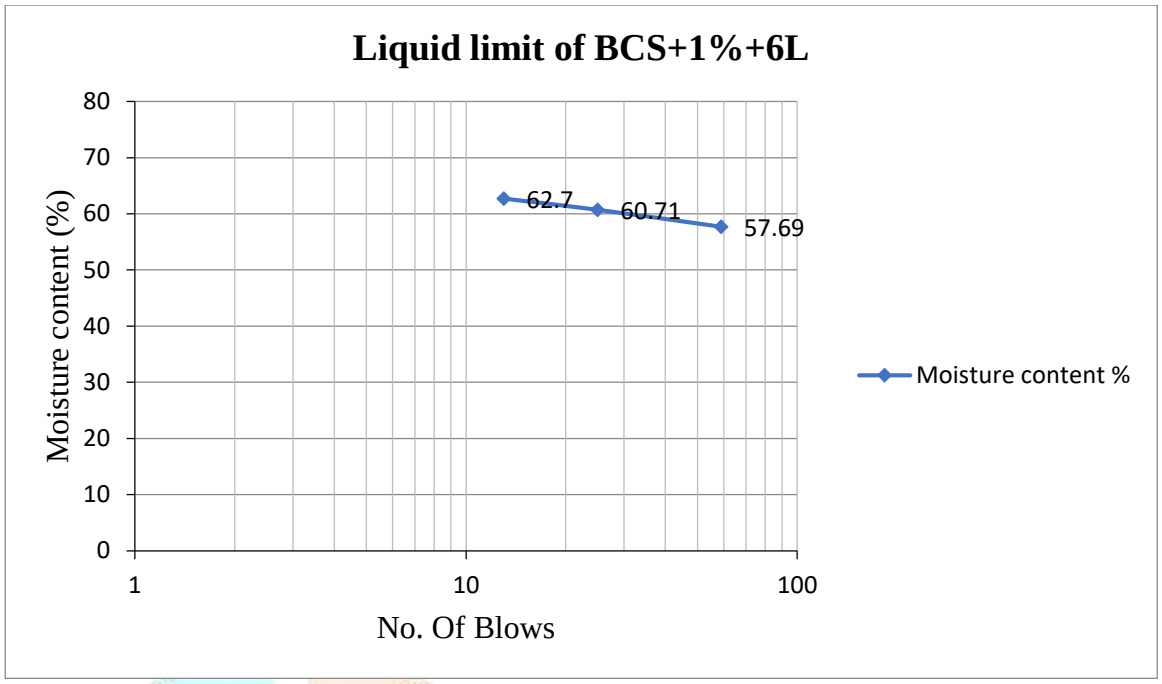


Fig 5.12: Liquid limit of BCS+1%+6L

From the results shown above it is observed that the optimum results are obtained when soil stabilization is done by reinforcing the soil with 0.75% recron fibre of 6mm length. A mark able improvement in the geotechnical properties is observed on its usage as shown in the above mentioned results.

ANALYSIS OF RESULTS

In the previous chapter we mentioned the results and now we will be analyzing results for obtaining an optimum amount of fibre to be used with Black Cotton soil

6.1SHRINKAGE LIMIT

6.1.1 BLACK COTTONS + 0.5% + 0L, 6L, 12L, 18L

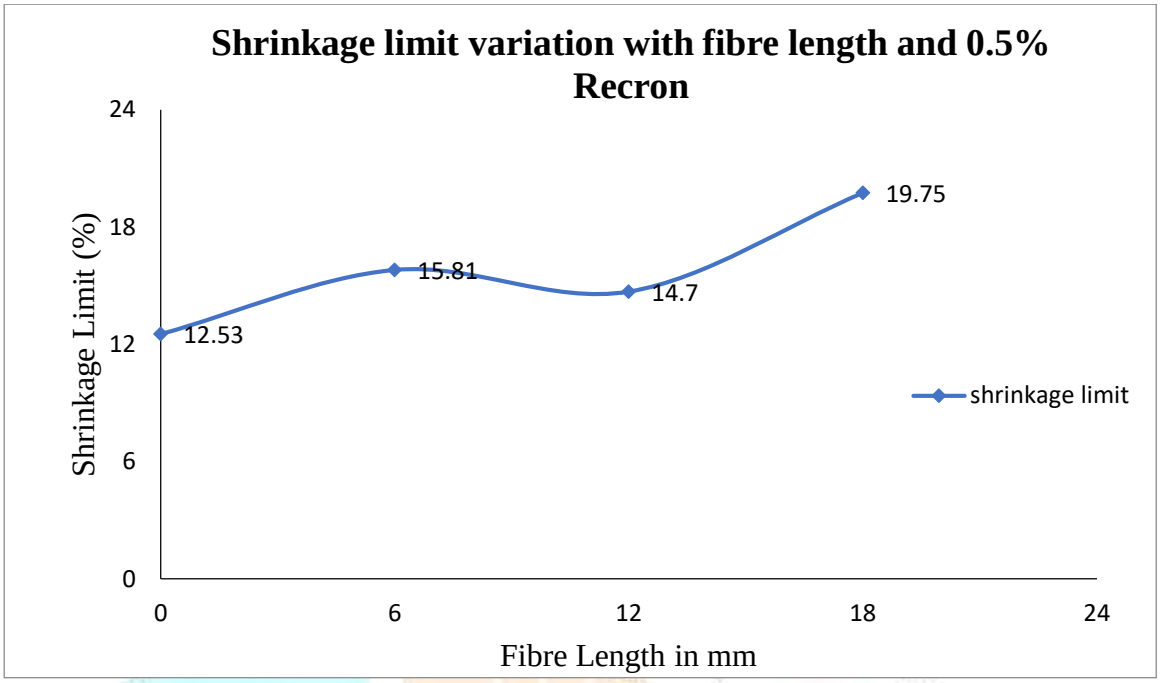


Fig. 6.1 – Shrinkage Limit Variation with fibre length &Recron

The shrinkage limit is the water content where further loss of moisture will not result in any more volume reduction. Hence after adding the fibre of different aspect ratios along with varying percentages a significant increase in shrinkage limit is observed which will control the swelling and shrinkage properties.

BSC + 0.75% + 0L, 6L, 12L

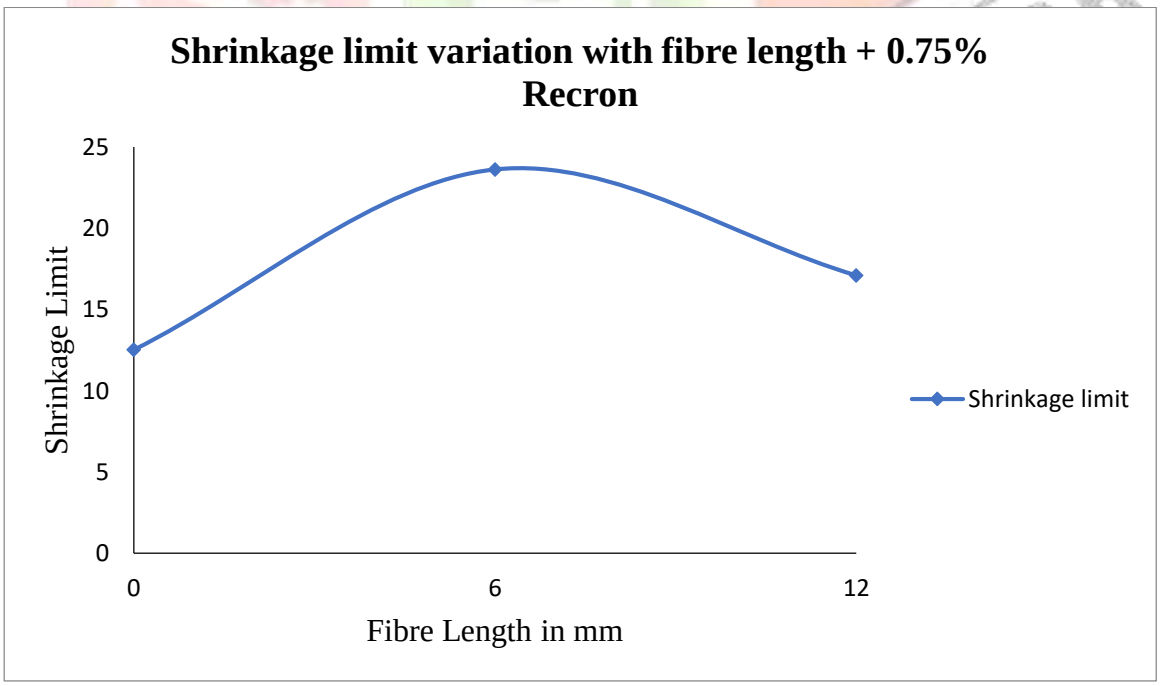


Fig 6.2 – Shrinkage Limit Variation with fibre length +0.75% Recron

A trend similar to the previous one is obtained when 0.75% recron is added with varying aspect ratios. Shrinkage limit has increased tremendously when 6mm fibre is used. With increasing Fibre content fibre having lower aspect ratio has higher values for shrinkage limit

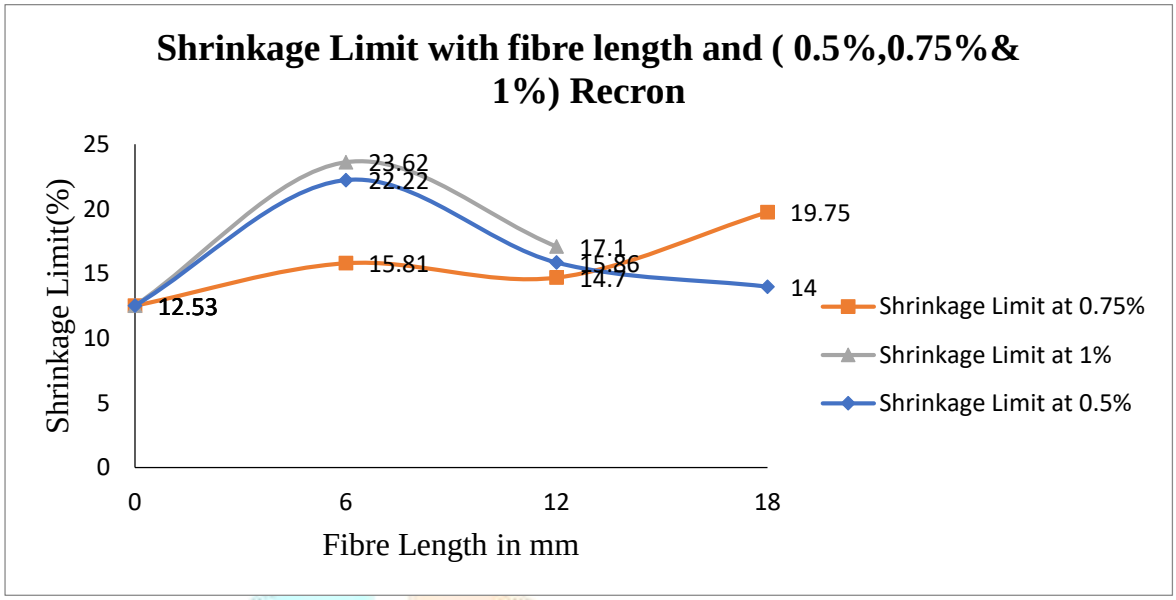


Fig 6.3: Shrinkage Limit with fibre length and (0.5%, 0.75%& 1%) Recron

6.1 LIQUID LIMIT

6.2.1 BCS + 0.5% + 0L, 6L, 12L

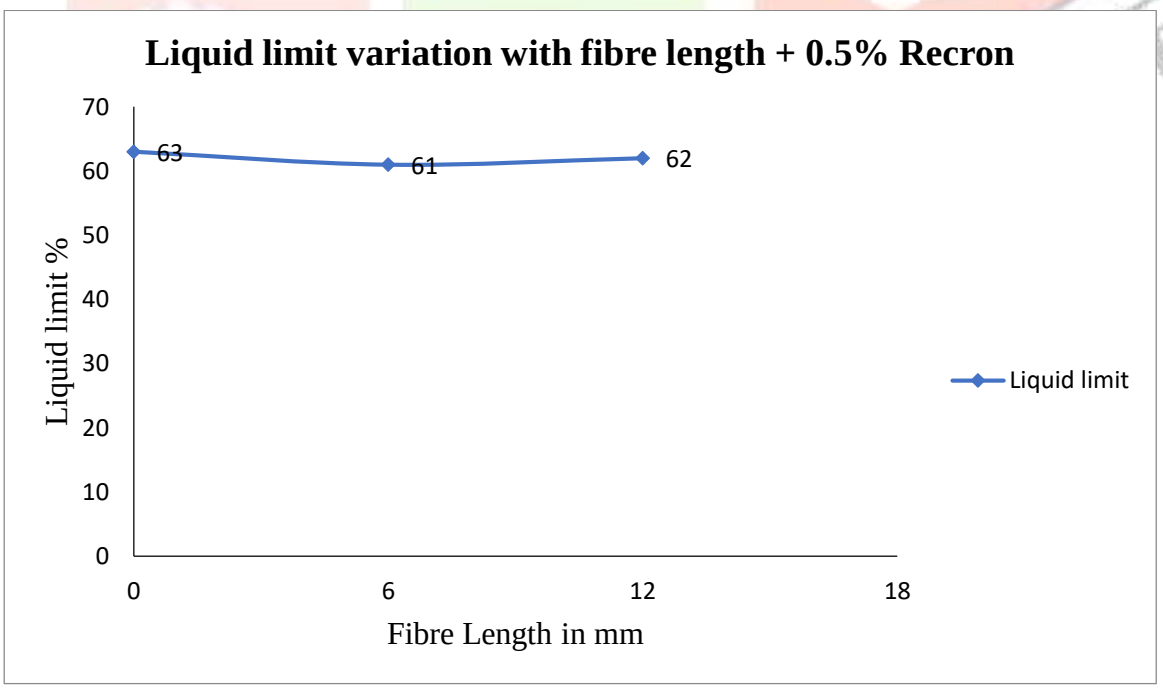
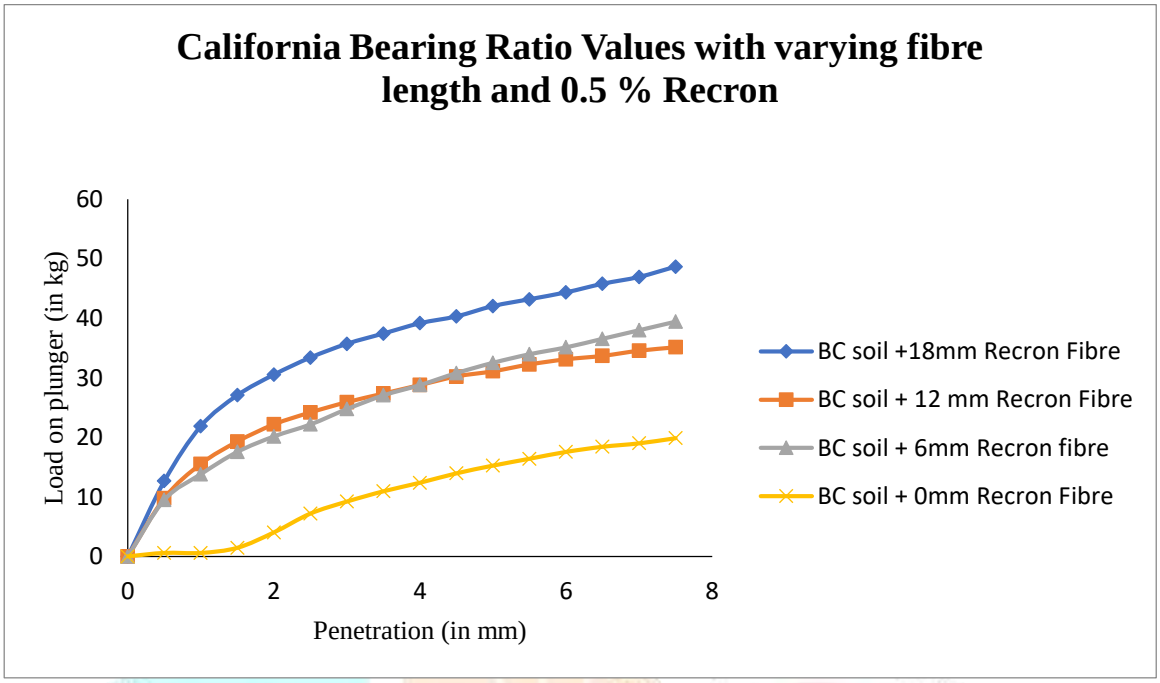


Fig 6.4 – Liquid Limit Variation with fibre length + 0.5% Recron

Liquid limit (W_L) is the change of consistency from plastic to liquid state .Consistency of a fine grained soil refers to its firmness which varies with the water content and after addition of Recron fibre liquid limit has decreased and hence an improved quality of Black Cotton soil is obtained. Results got better when fibre with lower aspect ratio is used.

6.2 CBR SOAKED

6.3.1 With 0.5% Recron



Fig, 6.5 – CBR values with varying fibre length & 0.5% Recron

The California Bearing Ratio (CBR) is a penetration test for the evaluation of the mechanical strength of the soil and after addition of Recron fibre CBR value increased. The increase in the CBR value is due to the reason that the inclusion of randomly distributed fiber into the soil improves its load and deformation behavior . Moreover the ingress of water decreases.

6.3 Triaxial with BLACK COTTONS + 0.5% + 0L, 6L, 12L, 18L

6.4.1 Cohesion Trend

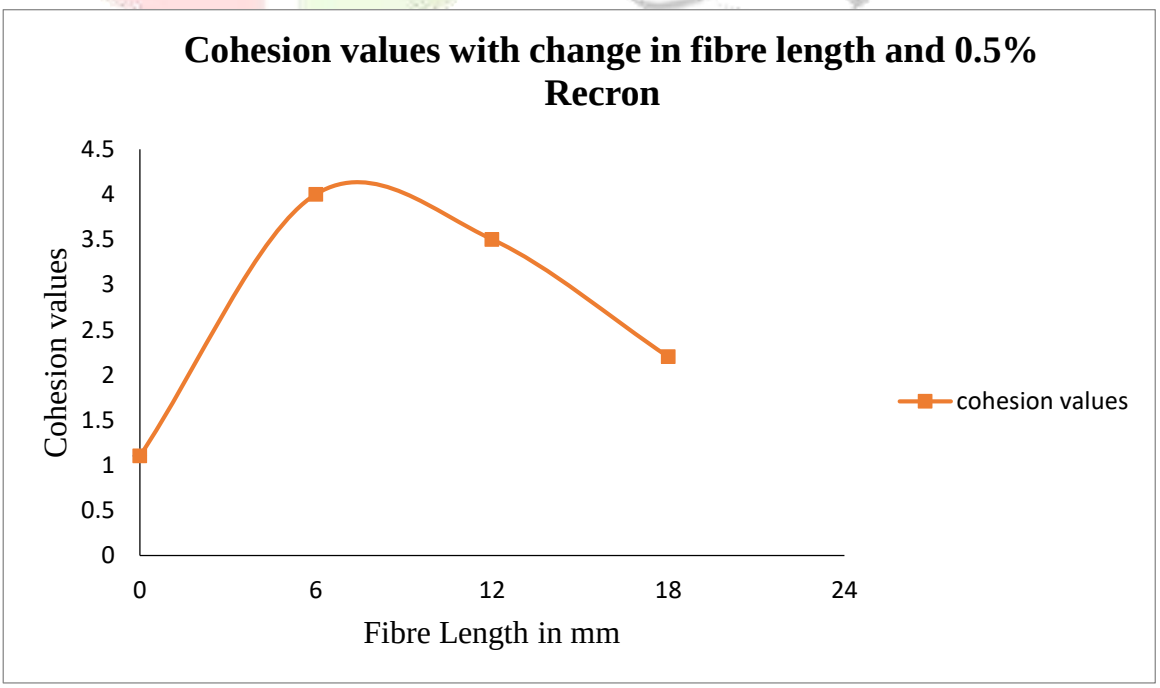


Fig.6.6 - Cohesion values with change in fibre length and 0.5% Recron

In Tri axial Compression test there is an increase in shear strength on the addition of Recron fibre better compaction is observed which has resulted in increased cohesion values and shear strength values.

Angle of shear resistance

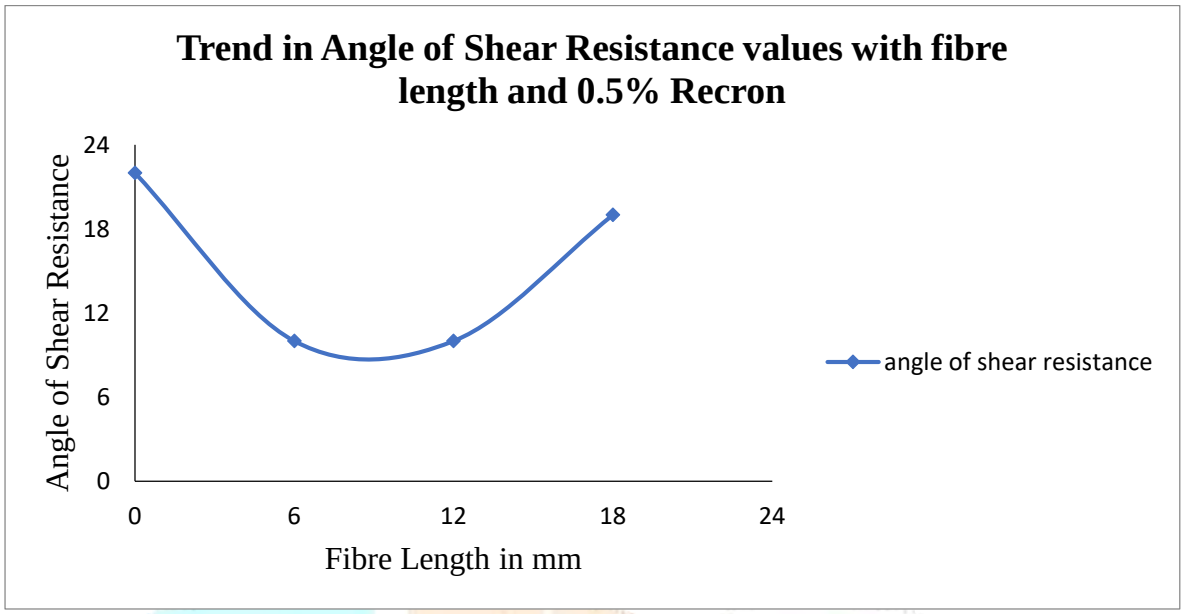


Fig.6.7 - Trend in Angle of Shear Resistance values with fibre length and 0.5% Recron

Better compaction increases the density which increases the cohesion values but decreases the value for angle of shear resistance.

6.5 Free swell index with BLACK COTTONS + 0.5% + 0L, 6L, 12L, 18L

Fig. 6.8 - Variation of Free Swell Index with Fibre Length at 0.5% Recron

As we add Recron fibre in Black Cotton soil free swell index decreases which means it swells less when comes in affinity of water. The best results are obtained on using fibre of length 6mm.

Comparison of 6mm Recron fibre with varying percentage of fibre

6.6.1 Shrinkage Limit

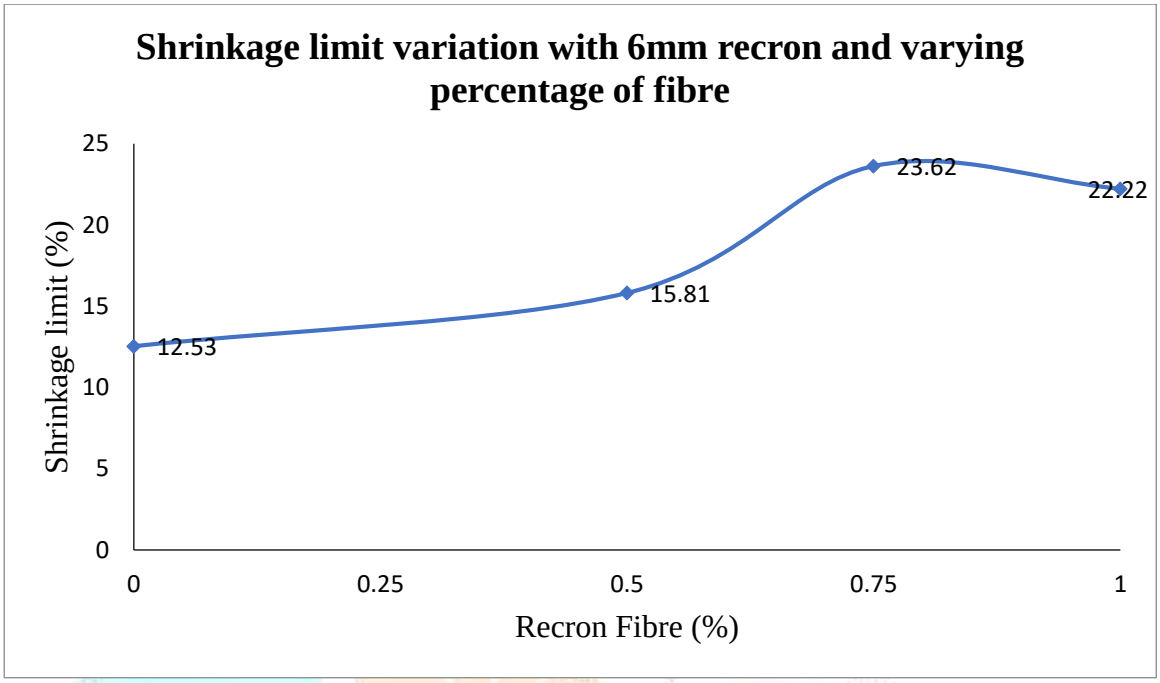


Fig 6.9: Shrinkage limit variation with 6mm recron and varying percentage of fibre

The graph above shows the comparison of shrinkage limit values when 6mm length Recron Fibre is used by varying its percentage in the Black Cotton soil and it is observed that 0.75% of Recron Fibre maximum shrinkage limit of 23.62% is obtained which is good as normal black cotton soil has shrinkage limit in the range of 8-14%.

6.5.1 Liquid Limit

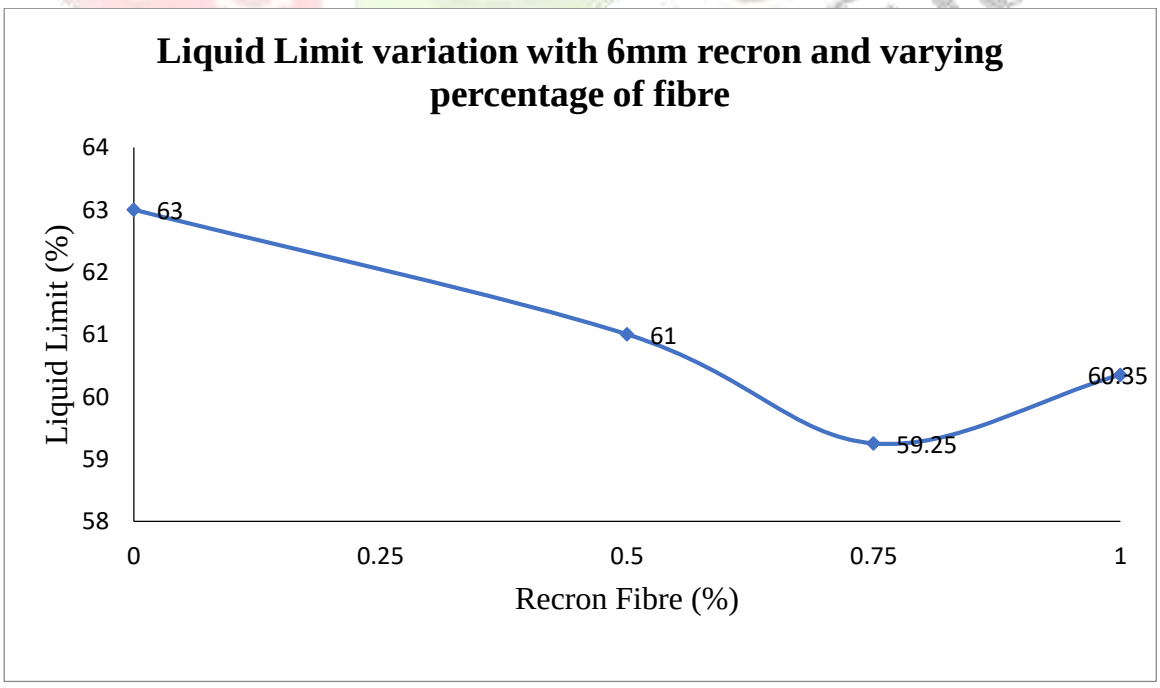


Fig 6.10: Liquid Limit variation with 6mm recron and varying percentage of fibre

Although there are not much drastic changes observed for liquid limit but still a decreasing pattern is observed which is satisfactory and in this case also optimized results are obtained with 0.75% 6mm Recron Fibre.

6.5.2 CBR

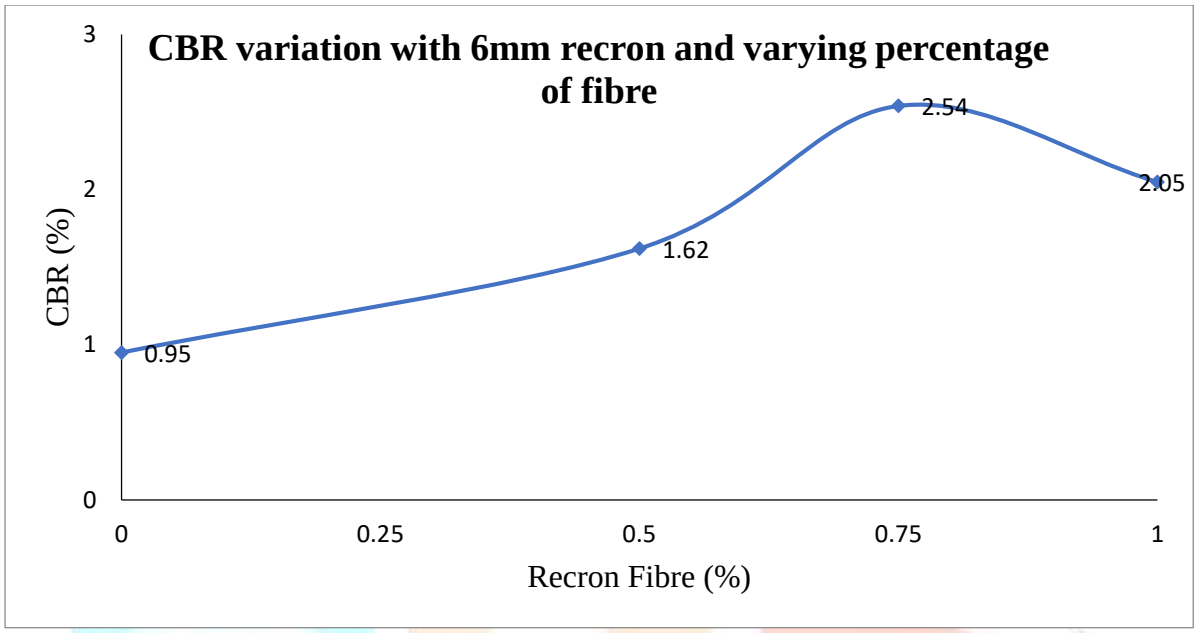


Fig 6.11: CBR variation with 6mm recron and varying percentage of fibre

On addition of Recron Fibre the California Bearing ratio value has improved which is clearly visible from the graph above and also 0.75% 6mm length Recron fibres give the optimized results when it comes to soil stabilization for this geotechnical property as well.

6.5.3 SHEAR PARAMETERS (C & ϕ)

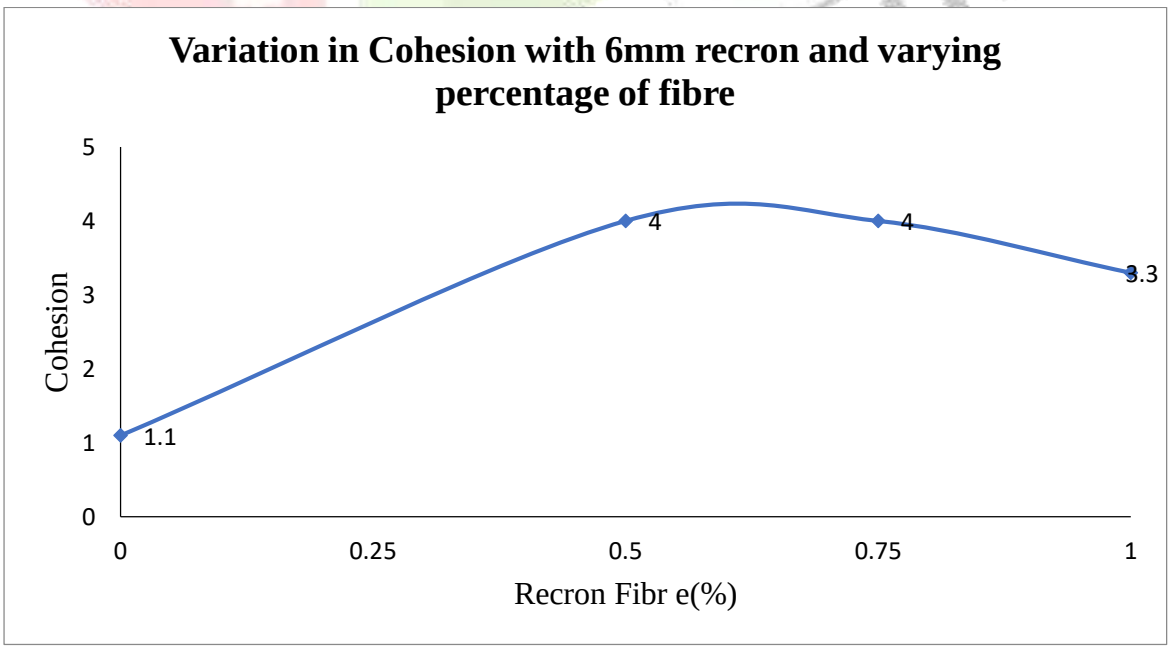


Fig 6.12: Variation in Cohesion with 6mm recron and varying percentage of fibre

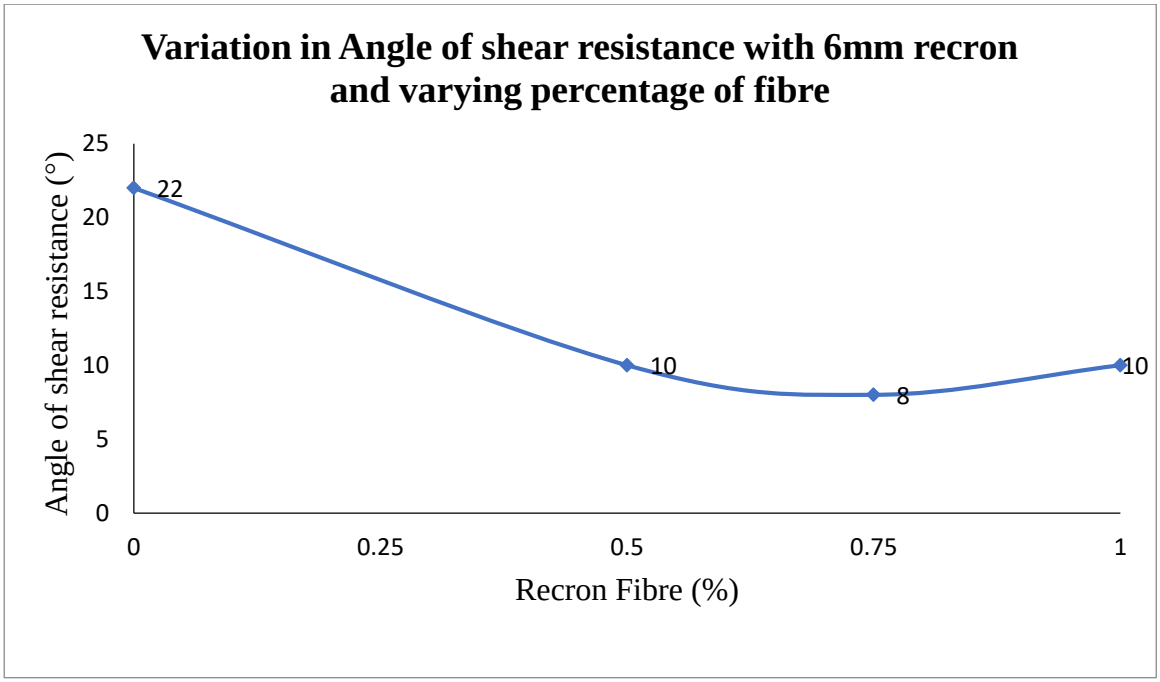


Fig 6.13: Variation in Angle of shear resistance with 6mm recron and varying percentage of fibre

6.5.4 Free swell index

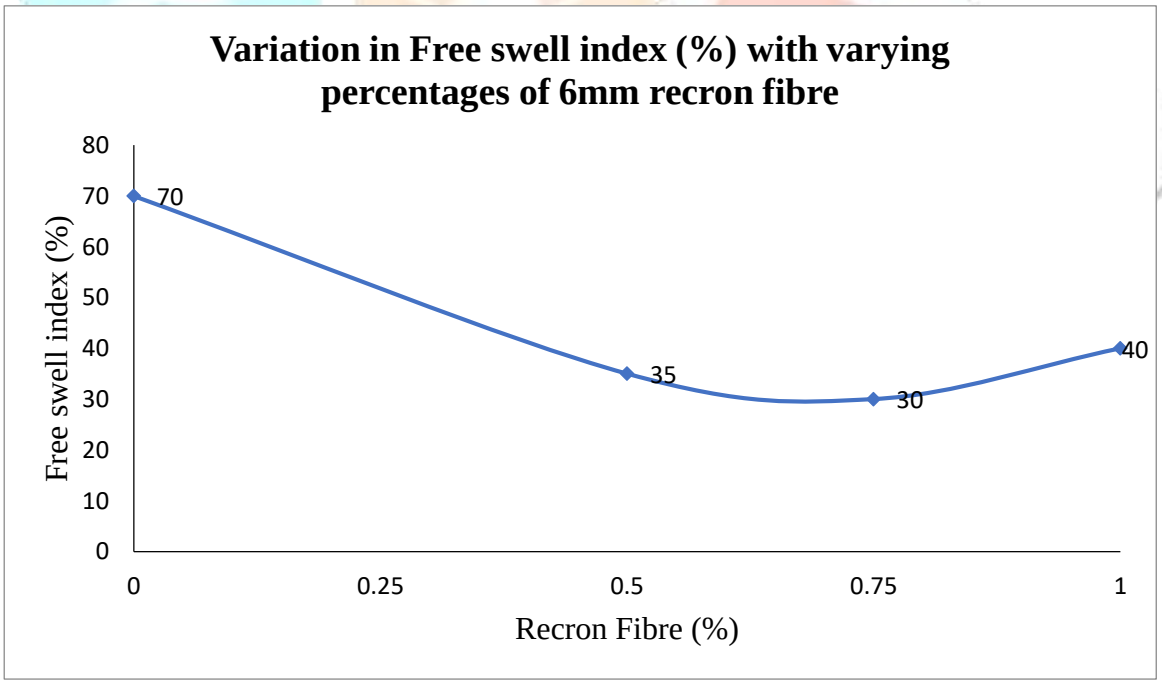


Fig 6.14: Variation in Free swell index (%) with varying percentages of 6mm recron fibre

After comparing geotechnical properties like shrinkage limit, liquid limit, California bearing ratio, shear strength parameters (c & ϕ), free swell index it can be observed that the shrinkage limit, California bearing ratio, along with the cohesion and free swell index values showed great improvements when stabilized by 0.75% of recron fibre of 6mm length however liquid limit did not show much improvement with its use.

Conclusion:

In this study we stabilized soil using Recron Fibre but as it can be seen from the literature review much better results can be obtained when Recron fibres are added along with some other industrial wastes. Simulation can be done for better analysis as it can be helpful during construction practices. While, this project concluded the following:

- After addition of recron fibre values for shrinkage limit, liquid limit, CBR and cohesion have improved.
- Tests were conducted by varying percentages of recron fibre as 0.5%, 0.75% and 1% along with the variation in aspect ratios as the lengths available were 6mm, 12mm and 18mm.
- On increasing the percentage of recron fibre it is observed that fibres with lower aspect ratio has shown better results which is also evident from the shrinkage and liquid limit.
- The optimum length of recron fibre to be used with Black Cotton Soil is observed to be 6mm as improvement in geotechnical properties which include shrinkage limit , liquid limit, CBR (soaked) for 6mm recron fibres is more than 12mm and 18mm recron fibre.
- Moreover the optimum percentage of recron fibres is observed to be 0.75% as the above mentioned geotechnical properties have enhanced with its use.
- Angle of shear resistance decreases as the void space is occupied by the recron fibres.
- On using 0.75% 6mm recron fibre California bearing ratio improved by 2.5 times as compared with Black Cotton soil without the addition of recron fibre.
- Shrinkage limit increased by 70% when 0.75% 6mm length recron fibres are used, moreover decrease by 42% in free swell index is also observed on using recron fibres in the above mentioned quantities.

References:

1. Muhammad Nawazish Husain, Praveen Aggarwal (IOSR-JMCE) 2015, “Application of Recron Fibre in Improving Silty Sub Grade Behavior.”

2. Sunila kumar Biradar, Shivaraj Biradar& A.D. Kotagond (IJREAT), 2014 “,Stabilization of BC Soil by using Lime and Recron Fibres.”

3. Brajesh Mishra (IJSR), 2014, “A study on Engineering Behavior of BC Soil and its Stabilization using Lime”

4. P.V. Koteswara Rao, K. Satish Kumar & T. Blessingstone (IJEST), 2012 “ Performance of Recron Fibres with Cement Kiln Dust in Expansive Soils”

5. Building Materials & Technology Promotion Council, Ministry of Urban Employment & Poverty Alleviation , Government of India

6. Muhammad Qasim, Aroj Bashir, Mubashar Tanvir, Malik Muhammad Anees ,IJRET (2005), "Effect of Rice Husk Ash on Soil Stabilization".

7. Gopal Ranjan, R. M. Vasan and H. D. Charan (ASCE), 1996, " Probabilistic Analysis of Randomly Distributed Fiber Reinforced Soil"

8. Jian Long Zheng, Rui Zhang and He-Ping Yang (ASCE), 2009, "Highway Subtraction Construction in Expansive Soil Areas".

9. Nandan. A. Patel, C. B. Mishra (IJSR), 2013, "Mapping the Improvement of Soil Strength Using Recron 3s Fibre".

10. Shailendra Singh, Hemant. B. Vasaikar (IJSR), 2013, "Stabilization of Black Cotton Soil Using Lime."

11. Supritha D K, J Ranjith, Kavya U S, Puneeth B (IJRET) 2016 "Stabilization Of Black Cotton Soil Using Iron Ore Tailings".

12. Recron 3s construction fibre by Reliance Industries Ltd.