Use of Lime and Waste Plastic Fibers for Subgrade Stabilization

R.Ratna Prasad, T.Venkateswararao, D.Auditya Sai Ram

Abstract: ***Black cotton soil is poor in shear and shows high swelling & shrinkage characteristics due to clay minerals. To utilize the soil as subgrade material, soil is blended with lime and plastic fibers. In the present investigation the level of lime utilized was 1% to 5% by dry weight of soil and percentage of plastic fibers 0.5% to 1.5%. Laboratory tests reveal that the ideal level of lime as 4%. Endeavors have been made with 4% lime and different rates of plastic fibers. Atterberg limits, standard proctor, modified compaction and CBR tests were led with lime and plastic fibers. The most extreme dry density of unadulterated soil increased from 17.59kN/m3 to 18.53kN/m3 by increase of lime from 0% to 5% and OMC diminishes from 21.5% to 14.146%. The expansion of 4% lime and 0.75% plastic fibers, the CBR esteem is expanded to 6.18% and for soil it is 2.01%, liquid and plastic limit values are diminished with % lime. This paper portrays the compaction and strength of clayey soil fortified with plastic fibers. Fiber utilized in this investigation is separated from waste plastic bags. Laboratory tests reveal that the ideal level of lime as 4%. Clayey soil with 4% lime indicates just minor increment in the quality of soil, repressing its utilization for ground changes. To additionally build the quality of the soil plastic fiber mix, ideal level of 4% of lime is included. The effect of aspect ratio, quantity of fiber on the conduct of the composite soil specimen with curing is studied. It is discovered that strength properties of optimum combination of soil-lime specimens fortified with plastic fibers is better than untreated BC soil or BC soil alone with plastic fiber. Lime treatment in BC soil enhances strength but it imparts brittleness in soil specimen. BC soil treated with 4% lime and reinforced with plastic fiber shows ductility behavior before and after failure. An optimum fiber content of 1% (by weight) with aspect ratio of 20 was recommended for strengthening BC soil.***

Keywords: ***Black cotton (BC) soil, Liquid limit, plastic limit, Plasticity Index (PI), Standard and Modified compaction, Optimum moisture content (OMC), Maximum dry density (MDD), California bearing ratio (CBR), Plastic Fibers (PF), Lime.***

I. INTRODUCTION

Soil stabilization is a technique in which interchanging or altering finer particles of soil with coarser particles takes place to enhance the required engineering properties of soil so that mixture of soil contain both cohesion and friction factors as well as high load carrying capacity when properly mixed, placed and compacted at site. The stabilized soil has the beneficial properties which depend upon the applications where soil is being used. Basically stabilized soil reduces the pavement thickness, eliminates the handling and hauling quantity of excavation material, gives higher resistance value, reduce the swelling characteristics and plasticity of clayey soil. In India BC soil is found in major parts of Madhya Pradesh and Andhra Pradesh. The Expansive soil covers about 20-25 % land area of India Due to the cyclic swelling and shrinking behaviour of black cotton soil, many problems are created during construction. Generally when the moisture content comes in the contact of Expansive soil its causes swelling and when moisture content reduce in the soil its causes shrinking. The estimated results show that the expansive soil causes the structural damage about $1000 Millions in USA, £150 UK, and many billions pounds in worldwide annually. There are many studies available in the literature regarding expansive soil. In present study, black cotton soil is stabilized with the help of lime and waste plastic fibers and was checked for economical uses as sub grade in pavements. Plastic fibers with different proportions such as 0%, 0.25%, 0.5%, 0.75%, 1% with respect to dry weight of soil has been used

II. MATERIALS

Soil

Black cotton soil utilized in the present examination was gathered from Nambur village near Guntur, Andhra Pradesh state, India. The soil collected was kept in controlled conditions in the laboratory and was tested as per the Indian Standard specifications given in the respective test codes. The essential tests were conducted in the laboratory for its characterization. The soil has 8.8% slit and clay, 87.8% fine sand fractions. The particle size distribution curve [IS: 2720 (Part 4)-1985] of the soil is exhibited in Fig.1. The different fundamental properties of soil are displayed in the Table.2.1.

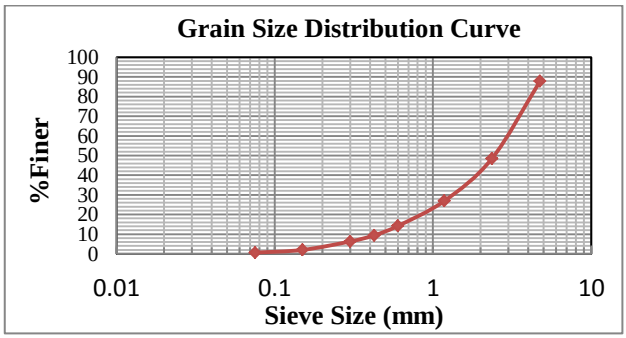

Fig.2.1.1 Grain Size Distribution of Black Cotton Soil

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R.Ratna Prasad, Assistant Professor, VVIT,Nambur,Guntur, Ap, India (venkateswararaothumati@gmail.com)

T.Venkateswararao, professor, VVIT,Nambur, Guntur, AP, India (rekapalli.rp@gmail.com)

D.Auditya Sai Ram, Assistant Professor, VVIT,Nambur,Guntur, AP, India (dasairam102@gmail.com)

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Table 2.1-Basic Geotechnical Properties of Black Cotton n Soil

Property	Value
Specific gravity	2.66
Standard proctor test (at OMC):	
Optimum Moisture Content, OMC (%) in Light Compaction	28.90
Maximum Dry Density, MDD(KN/m^3)	15.48
Compaction Results(at OMC):	
Optimum Moisture Content, OMC (%)in Modified Compaction	21.50
Maximum Dry Density, MDD (kN/m^3) in Modified Compaction	17.60
California Bearing Ratio Values, CBR (%) (at OMC):	
CBR (%) in Modified Compaction	2.01
Grain Size Distribution:	
% Fine Sand	87.8
% Silt & Clay	8.8
Effective Diameter, D_{10} (mm)	0.39
Coefficient of Uniformity, c_u	8.21
Coefficient of Curvature, c_c	1.57
Soil Classification	SW

Lime

The lime used in this investigation was taken in powder form. The various properties of lime are presented in the tables 2.2. The lime proportions adopted are 0%, 1%, 2%, 3%, 4% and 5%.

Table No 2.2. Chemical composition of lime

Chemical Configuration Ca(OH)2	
Minimum assay (%)	90.00
Maximum limits of impurities (%)	
Chloride (CL)	0.01
Sulphate (SO_4)	0.2
Arsenic (As)	0.0004
Lead (Pb)	0.001
Hydrochloric acid insoluble matter (%)	1

Plastic Fibers

The plastic fibers used in this investigation were collected from Mangalagiri town, Andhra Pradesh, India and are extracted from waste plastic bags. The different percentages of fibers such as 0%, 0.25%, 0.5%, 0.75% and 1% are used with required lime content. The properties of plastic fibers are displayed in Table 2.3.

Table 2.3 Properties of Plastic Fibers

Specific gravity	0.87
Tensile strength(N/mm^2)	157.30

III. TEST PROCEDURE

Grain Size Distribution

The grain distribution test was conducted according to the specifications given in the IS: 2720 (Part 4)-1985and is shown in fig.2.1.1. From the graph grain size distribution in soil and parameters Cu and Cc are calculated and presented in table 2.1

Specific Gravity Test

This test is done by using specific gravity bottle as per the specifications in IS: 2720 (Part 3/Set I)-1980. Specific gravity of soil ranges from 2.5 to 2.8 depending up on the mineral present in the soil. The specific gravity of soil is reported as 2.66.

Free Swell Test

The test was conducted to measure the degree or expansiveness of given soils. The degree of expansiveness and possible damage to lightly loaded structure may be qualitatively determined by a parameter free swell index and for soil it is observed as 50% and for soil + 4% lime is 35.7%.

Plastic Limit Test

The plastic limit of tested soil is 15.38% and its value decreases to 11% as the lime percentage increases from 1% to 5%.

Liquid Limit Test

The liquid limit of soil depends upon the clay mineral present, stronger the surface charge and thinner the particle, the higher will be the amount of absorbed water and therefore more will be the liquid limit. The liquid limit of tested soil is 64% and its value decreases to 50.4% as the lime percentage increases from 1% to 5%.

Modified Compaction Test

This test is done to determine the maximum dry density and optimum moisture content of the soil and lime +plastic fibers + soil mixtures. IS modified compaction tests have been led as per IS: 2720 (Part 7)-1980 on the soil with various contents of plastic fibers and lime.

California Bearing Ratio Test

This is a penetration test for assessing the stability of soil sub grade with lime and plastic fibers as per IS: 2720.

IV. TEST RESULTS

Plastic Limit Characteristics

The variation of the plastic limit of sample with different lime content is presented in fig.3.1. From the graph it may be seen that the addition of lime results in a steady decline in the plastic limit of the soil. The decrease of plastic limit is significant for 4% lime and further increase shows slight increase in plastic limit.

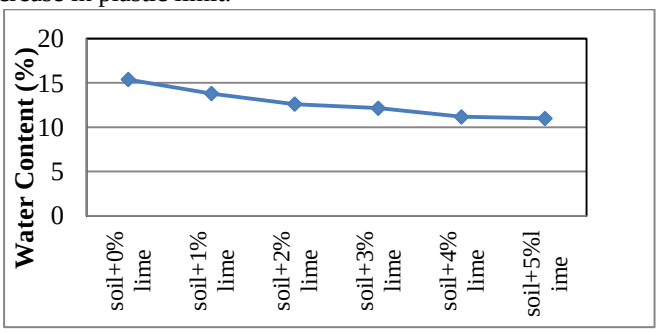

Fig.3.1 Variation of plastic limit with soil+ % lime

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Liquid Limit Characteristics

It is evident from the fig.3.2 that liquid limit diminishes with the addition of lime shows a considerable decline in liquid limit up to 5% increase in lime percentage in the soil. The liquid limit of the black cotton soil is essentially controlled by thickness of the diffused double layer. The expansion of lime results in the decrease of liquid limit because of the impact of decrease in diffused twofold layer thickness and also because of the impact of weakening of clay content of the blend. The diminishing of liquid limit is very marginal due to the increased dilution effect i.e. because of the expanded level of coarser size particles in the blend on account of the expanded level of lime.

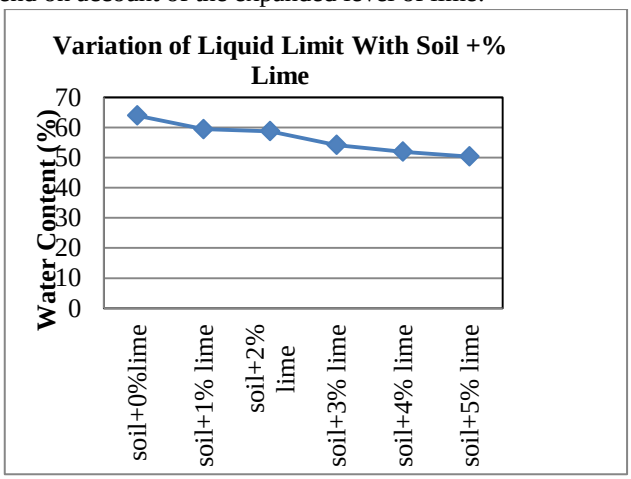

Fig.3.2 Variation of Liquid Limit with Soil+% lime

Plasticity Index

Plasticity Index gives the plasticity character of expansive soils. The variation of PI values with different percentage of lime content is presented in fig.3.3

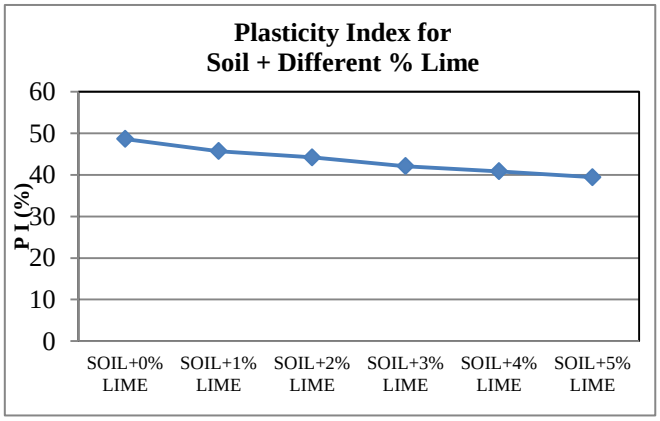

Fig.3.3 Variation of plasticity index values for soil+ different % lime

Compaction Characteristics

The optimum moisture content of the soil decreases from 21.5% to 13.5% with increase of lime content from 0% to 5% and at the same time the maximum dry density values increases from 17.59kN/m3 to 18.34kN/m3 with percentage of lime. The values are tabulated in table 3.3 and different curves are drawn and are shown in figures.3.4.1 to 3.4.5 to analyze different parameters with respect to water content

Table 3.4 Values of MDD and OMC of Soil with Different Combinations of Lime

Material	Dry Density, γ_d (gm/cm^3)	O.M.C (%)
Soil+0% lime	1.759	21.5
Soil+1% lime	1.805	17.06
Soil+2% lime	1.8120	16.46
Soil+3% lime	1.838	15.76
Soil+4% lime	1.8527	14.15
Soil+5% lime	1.834	13.84

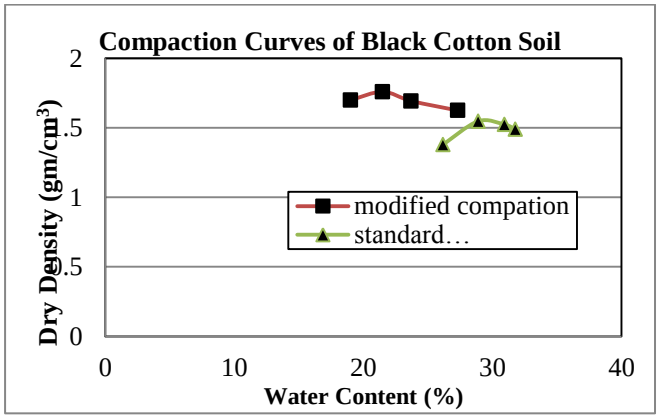

Fig.3.4.1 Comparison of light and heavy compaction values for black cotton soil

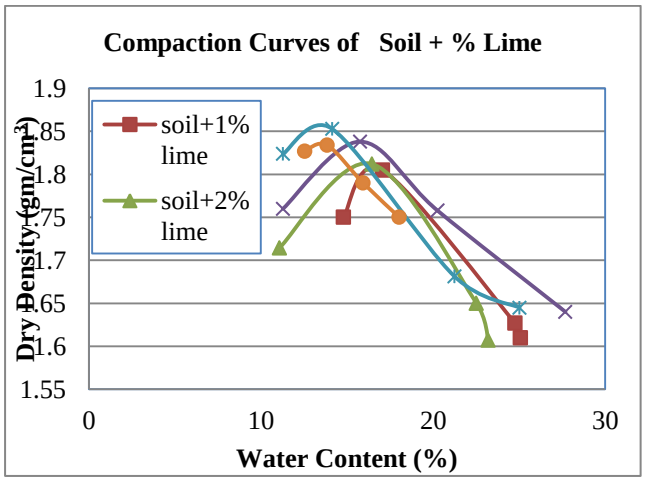

Fig.3.4.2 Compaction values for soil + lime with different combinations

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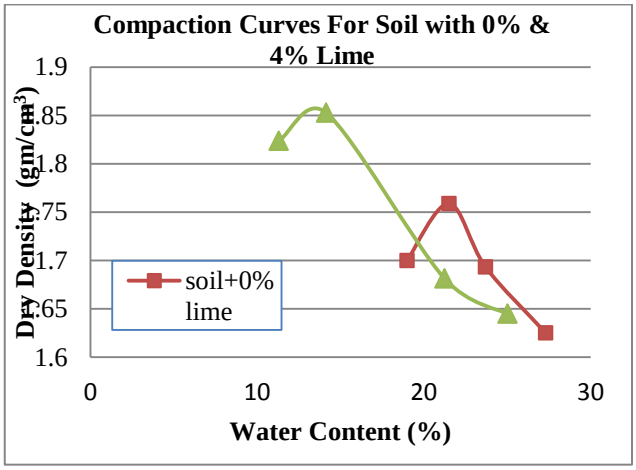

Fig.3.4.3 Compaction curves for soil with 0% and 4% Lime

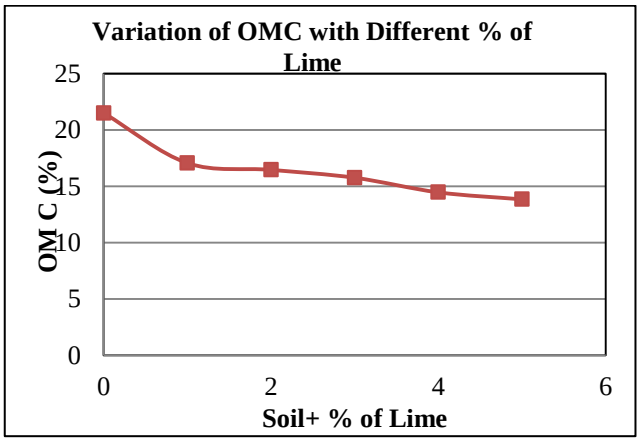

Fig.3.4.4 Variation of optimum moisture content with different lime content

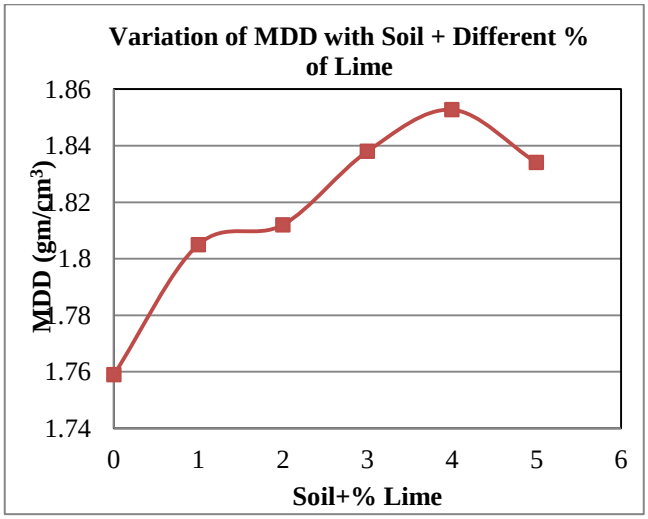

Fig.3.4.5 Variation of maximum dry density values with different lime content

CBR (California Bearing Ratio) Characteristics

In the developments of roads for low volume and heavy volume traffic conditions, the CBR is the major significant parameter for sub grade in arriving at the suitable pavement thickness. To comprehend CBR variations of plastic fiber and lime black cotton soil mixtures, a laboratory testing was conducted for the conditions of modified compaction. The results of CBR for modified compaction are presented in Figures.3.5.1 to 3.5.4. The load penetration curves in a un-soaked condition for black soil tested under modified compaction is presented in Fig.3.5.1

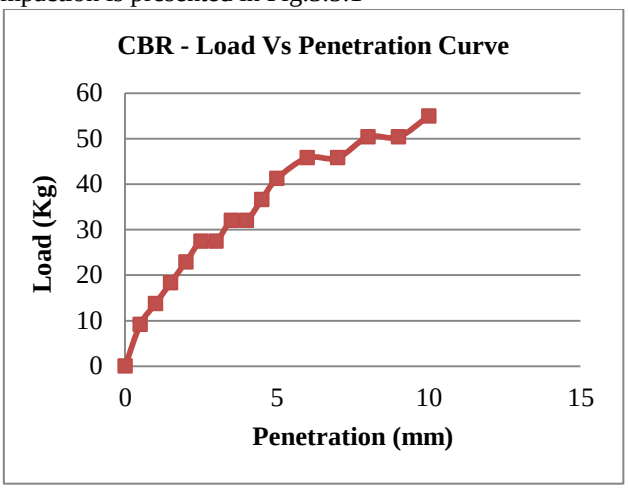

Fig.3.5.1 Load vs. penetration curve for soil

Table.3.5 Values of CBR with Soil+ Different Percentages of Lime

Material	CBR (%)
Soil+0% lime	2.01
Soil+1% lime	3.34
Soil+2% lime	3.51
Soil+3% lime	3.68
Soil+ 4% lime	3.84
Soil+5% lime	3.74

Table.3.6 Values of CBR with Soil+4% Lime +% of PF

Material	CBR (%)
Soil+4% lime + O% PF	3.84
Soil+4% lime +0.25% PF	3.94
Soil+4% lime +0.5% PF	4.18
Soil+4% lime +0.75% PF	6.18
Soil+4% lime +1% PF	5.01
Soil+4% lime +1.25% PF	3.99

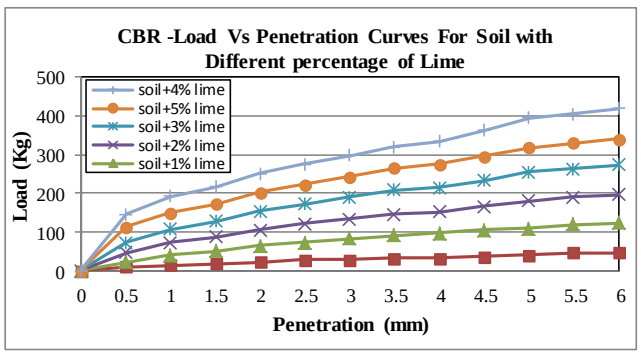

Fig.3.5.2 Load vs. penetration curves for soil with different lime percentages

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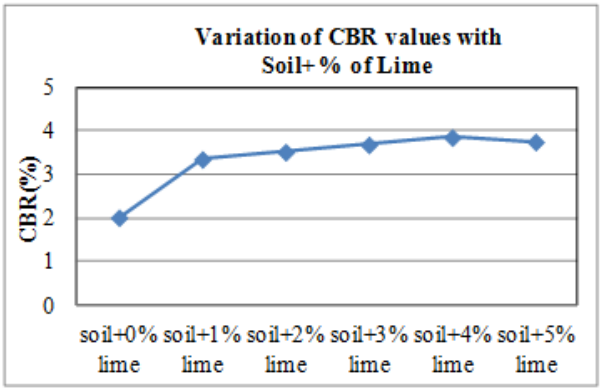

Fig.3.5.3 Variation of CBR values with soil+% lime

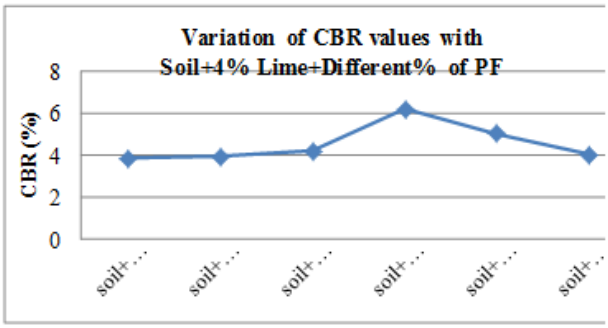

Fig.3.5.4 Variation of CBR values with soil+4% lime+% of PF

CONCLUSIONS

1. In modified proctor test, the optimum moisture content gradually decreased from 21.5% to 13.84% when lime content increased from 1% to 5%.
2. The maximum dry density values increased from 17.59kN/m3 to 18.527 KN/m3 for 1 % to 4% lime content. But after adding 5% lime, the maximum dry density value gets decreased. Therefore the optimum values are obtained for a soil blended with 4% lime and the corresponding optimum moisture content is 14.1463% and the maximum dry density is 18.527 KN/m3.
3. CBR value for black cotton soil is 2.005%. After adding lime content to soil, the CBR values increased from 3.3416% to 3.8428% for 1% to 4% lime. But from 5% lime content the CBR values gets decreased. In another study there is a gradual increase of CBR values from 3.9416% to 6.1819% with inclusion of plastic fiber content from 0.25% to 0.75% and the values decreased with further addition of PF percentage. The maximum CBR value is observed for soil added with 4% lime and 0.75% Plastic fibers.
4. The Free Swell Index for black soil is obtained as 50% and its value is decreased to 35.7% for soil blended with 4% lime.
5. The Specific Gravity for black cotton soil is 2.6 and its value decreased to 2.33 for soil blended with 4% lime.
6. The Liquid Limit has reduced from 64% to 50.4%, with addition of 4% lime to the black soil.
7. The Plastic Limit has reduced from 15.38% to 11% with addition of 4% lime to the black soil.
8. The Plasticity Index values have reduced from 48.62% to 39.40% with mix of 4% lime to black soil.
9. Hence there is an improvement of properties of black soil by adding lime 4% and plastic fibers 0.75% by weight of dry soil to utilize them as an engineering material for various purposes such as foundation soil, pavement sub grade etc.

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T.Venkateswararao working as Assistant Professor, VVIT,Nambur,Guntur District. He has 4 years experience in soil mechanics and foundation engineering area. He has completed M.tech at jntu Kakinada. Mail: venkateswararaothumati@gmail.com,

Dr.R.Ratna Prasad working as professor, VVIT,Nambur, Guntur District First. He has more than 20yrs experience in soil mechanics and foundation engineering. He has completed his Ph.D at jntu Kakinada. Mail: rekapalli.rp@gmail.com

D.Auditya Sairam working as Assistant Professor, VVIT,Nambur,Guntur District. He has 4 years experience in structural engineering area. He has completed M.tech at jits college of engineering. Mail : dasairam102@gmail.com