Experimental Study on Soil Stabilization using Admixtures

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Abstract

Stabilization of Black Cotton Soil (BC soil) is studied by using Lime and Fly ash. BC soils are highly clayey soils (Montmorillonite clay mineral). This paper includes the evaluation of soil properties like Optimum moisture content, dry density. Different quantities of Lime and Fly ash (% by weight) are added to the BC soil and the experiments conducted on these soil mixes. The moisture changes in BC soils, compressibility and plasticity nature can be greatly improved with the addition of Lime and Fly ash. . Different quantities of Lime and Fly ash (% weight) are added to the BC soil and the experiments conducted on these soil mixes. The result shows that the use of Lime and Fly ash increases the soil stabilization.

Keywords: Black cotton soil, lime, fly ash, Sieve Analysis, Specific gravity, Compaction test

I. INTRODUCTION

Soil stabilization is a technique aimed at increasing the stability of soil mass and chemical alteration of soils to enhance their engineering properties. The soil is hard as long as it is dry but loses its stability almost completely on wetting. On drying, the soil cracks very badly and in the worst cases, the width of cracks is almost 150mm and travel down to 1.5m below ground level. The construction cost can be considerably decreased by selecting local materials including local soils for the construction of the lower layers of the pavement such as the sub-base course. If the stability of local soil is not adequate for supporting wheel loads, the properties are improved by soil stabilization technique. Fly ash is a waste product from Thermal Power Plants, Which use coal as fuel. It around 100 to 110 million tons of fly ash is being produced from different thermal power plants in India. Stabilization of course-grained soils having little or no fines can often be accomplished by the use of Lime and Fly ash combination. Lime and Fly ash in combination can often be used successfully in stabilizing granular materials. Lime and Fly ash stabilization is often appropriate for base and sub-base course materials. The water content of the fly ash stabilized soil mixture affects the strength. The maximum strength realized in soil-fly ash mixtures generally occurs at moisture contents below optimum moisture content for density. As according to ASTM C-618, two major classes of fly ash are recognized i.e. Class C and Class F. These two classes are related to the type of coal burned. Class F fly ash is normally produced by burning anthracite or bituminous coal while Class C fly ash is generally obtained by burning sub bituminous or lignite coal. Therefore, essentially all Class F fly ashes presently available are derived from bituminous coal. Class F fly ashes with calcium oxide (CaO) content less than 6%, designated as low calcium ashes, are not self-hardening but generally exhibit pozzolanic properties. These ashes contain more than 2% unburned carbon determined by loss on ignition test. Quartz, mullite and hematite are the major crystalline phases identified fly ashes, derived from bituminous coal. In the presence of water, the fly ash particles produced from a bituminous coal react with lime or calcium hydroxide to form cementing compounds similar to those generated on the hydration of Portland cement. Class C fly ashes, containing usually more than 15% CaO and also called high calcium ashes, became available for use in concrete industry only in the last 20 years in the 1970s. Class C fly ashes are not only pozzolanic in nature.The specific gravity of fly ash is reported to be related to shape, color as well as chemical composition of fly ash particle.

II. MATERIALS

A. *Black Cotton Soil:*

Natural soil sample is taken from Utnal village near Vijayapur (Karnataka),from depth of 2.5 m from ground level. The soil was air dried and pulverized manually. Natural soil has the swelling and shrinkage properties in the present of moisture. This natural soil is grey and black in colour. Basic properties of the natural untreated soil used in experiment work are presented in table 1.

Table – 1

S No.	*Soil properties*	*Values*
1	*Gravel*	*23.4%*
2	*Sand*	*76%*
3	*Silt & Clay*	*0.60%*
4	*Liquid Limit*	*38.9%*
5	*Plastic Ilimit*	*14.4%*
6	*Plastic Index*	*24.5%*
7	*OMC*	*15.73%*
8	*MDD*	*1.76 gm/cm3*
9	*CBR*	*2.166*

B. *Fly Ash:*

Class-F fly ash is taken from Thermal Power Plant Raichur (Karnataka). Fly ash is air dried and pulverized. Fly ash is waste by product of Thermal power plant. Fly ash by itself has little cementatious value but in the presence of moisture it reacts chemically and forms cementatious compounds and attributes to the improvement of strength and compressibility characteristics of soils. The basic constituents of fly ash are shown in table 2.

Table – 2

S.NO.	*Constituent of fly ash*	*Values*
1	*Silica(SiO 2)*	*60.00*
2	*Alumina(Al 2O3)*	*25.00*
3	*Ferric oxide(Fe 2O3)*	*8.12*
4	*Calcium oxide(CaO)*	*2.9*
5	*Magnesium oxide (MgO)*	*0.82*
6	*Titanium oxide(TiO 2)*	*0.24*
7	*Free lime content*	*2.75*

C. *Lime*

Lime was generally used from Shastri market Vijayapur (Karnataka).
The basic constituents of lime are shown in table 3.

Table – 3

S.NO.	*Constituent of fly ash*	*Values*
1	*Silica(SiO 2)*	*60.00*
2	*Alumina(Al 2O3)*	*25.00*
3	*Ferric oxide(Fe 2O3)*	*8.12*
4	*Calcium oxide(CaO)*	*2.9*
5	*Magnesium oxide (MgO)*	*0.82*
6	*Titanium oxide(TiO 2)*	*0.24*
7	*$CaCO_3$*	*2.75*

III. SOIL PREPARE & EXPERIMENT

Fly ash is mixed in varying percentage of 10%, 15%, 20%, 25%and 30% with natural soil. Lime are mixed in varying percentage of 10%, 15%, 20%, 25%and 30% with natural soil.

The fly ash, lime & black cotton soil are mixed fully on dry weight basis in the suitable required proportions. There are different test Standard Proctor Test, Modified Proctor Test, were performed in laboratory as per IS code standards.
The following tests are conducted:

- Sieve Analysis
- Specific Gravity Test
- Liquid Limit Test
- Plastic Limit Test
- Standard Proctor Test
- Modified Proctor Test

IV. RESULT AND DISCUSSION

A. Sieve Analysis:

Soil having particles larger than 0.075mm size is termed as course grained soils. In these soils more than 50% of the total material by mass is larger than75 micron. Coarse grained soil may have boulder, cobble, gravel, and sand.
Results of Sieve Analysis shows in table I

Table – 1

SL NO	*Sieve Size*	*Empty wt of Sieve(W1)*	*Sieve+ Soil(W2)*	*Soil Retained (W2-W1)*	*%of Soil Retained*	*Cumulative % Retained*	*Percentage Finer*
1	*4.75*	*427*	*1108*	*681*	*68.1*	*68.1*	*31.9*
2	*2.36*	*389*	*450*	*61*	*6.1*	*74.2*	*25.8*
3	*1.18*	*314*	*434*	*120*	*12*	*86.2*	*13.8*
4	*600*	*373*	*444*	*71*	*7.1*	*93.3*	*6.7*
5	*425*	*303*	*329*	*26*	*2.6*	*95.9*	*4.1*
6	*300*	*319*	*345*	*26*	*2.6*	*98.5*	*1.5*
7	*150*	*302*	*313*	*11*	*1.1*	*99.6*	*0.4*
8	*75*	*301*	*303*	*2*	*0.2*	*99.8*	*0.2*
9	*Pan*	*354*	*355*	*1*	*0.1*	*99.9*	*0.1*

B. Specific Gravity Test

The Specific Gravity of Soil can be determined in Laboratory using Pycnometer .Specific Gravity is the ratio of the mass/weight in air of a given volume of dry soil solids to the mass/weight of equal volume of water.

G = W2-W1/ (W2-W10)-(W3-W4)

W1 = Empty weight of Bottle
W2 = Empty weight of Bottle + Soil
W3 = Empty weight of Bottle + Soil + Water
W4 = Empty weight of Bottle + Water

V. RESULTS OF SPECIFIC GRAVITY TEST

Table – 2

SL No	*Mix Proportion*	*Specific Gravity*
1	*SOIL*	*2.5*
2	*SOIL+ FLYASH 10%*	*2.1*
3	*15%*	*2.0*
4	*20%*	*1.9*
5	*25%*	*1.88*
6	*30%*	*1.86*
7	*SOIL+ LIME 10%*	*2.49*
8	*15%*	*2.54*
9	*20%*	*2.6*
10	*25%*	*2.62*
11	*30%*	*2.65*

A. Liquid limit

Table – 3

S. No	*Types Of Soil*	*Liquid Limit Test*	*Plastic Limit Test*
1	*B.C. SOIL*	*60.20%*	*45%*
2	*B.C. SOIL+ 10% FLY ASH*	*45.13%*	*42%*
3	*B.C. SOIL +15% FLY ASH*	*40%*	*41.8%*
4	*B.C. SOIL +20% FLY ASH*	*37%*	*40.4%*
5	*B.C. SOIL +25% FLY ASH*	*35%*	*38.5%*
6	*B.C. SOIL +30% FLY ASH*	*33%*	*37%*
7	*B.C. SOIL+10% LIME*	*56%*	*40%*
8	*B.C. SOIL+15% LIME*	*54%*	*38.5%*
9	*B.C. SOIL+20% LIME*	*54.12%*	*37.4%*
10	*B.C. SOIL+25% LIME*	*50%*	*35.2%*
11	*B.C. SOIL+30% LIME*	*48.4%*	*34%*

Liquid limit of black soil is decreases with addition of fly ash content. The primary clay mineral present in the black cotton soil is montmorillonite. The variation of liquid limit on addition of fly ash to the black cotton soil is shown in fig.1

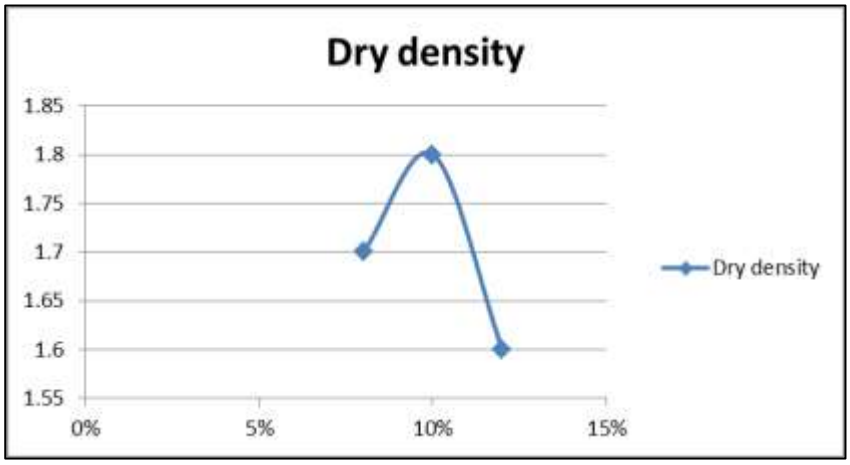

Fig. 1: Liquid limit

Increased addition of fly ash with BC soil, the amount of soil to be flocculated decreases and the finer particles of fly ash may be incorporated in the voids of flocculated soil; thereby decreasing the water held in the pores leading to the decrease in the plastic limit The variation of plastic limit on addition of fly ash to the black cotton soil is shown in fig. 2.

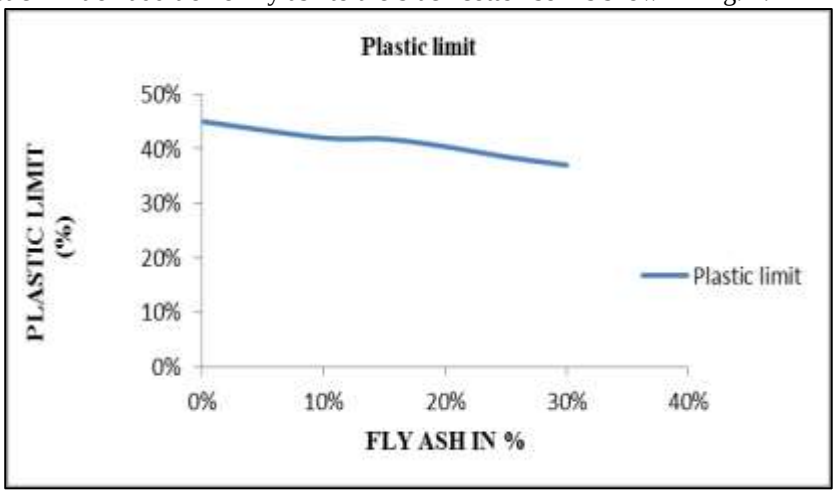

Fig. 2: Plastic limit

)) Liquid Limit

Liquid limit of black soil is increases with addition of lime content.

The variation of liquid limit on addition of lime with the black cotton soil is shown in fig.6.

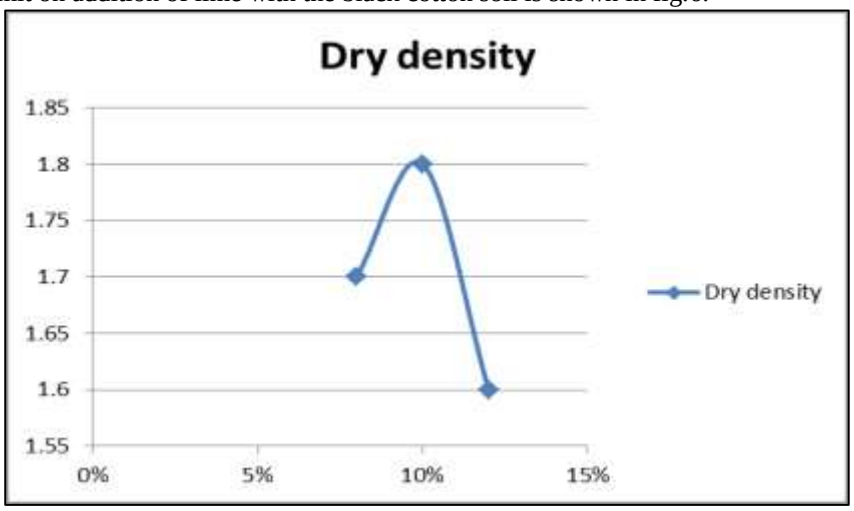

Fig. 3: Liquid limit

2) Plastic Limit

The variation of plastic limit on addition of lime with the black cotton soil is shown in fig. 4.

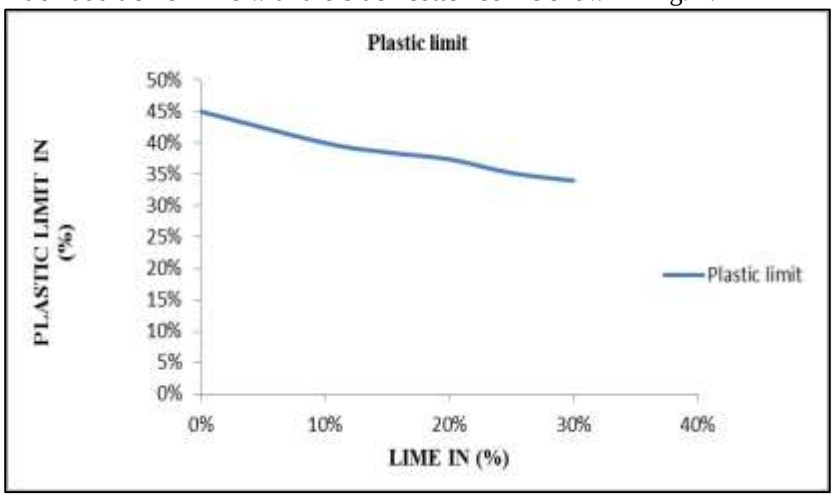

Fig. 4: Plastic limit

Standard Proctor and Modified Proctor Test

The tests results of varying % fly ash and lime with BC soil is shown in table 4

Table – 4

S. No	*TYPES OF SOIL*	*Standard procter test*		*M0dified procter test*	
		OMC (%)	*MDD (g/cm^3)*	*OMC (%)*	*MDD (g/cm^3)*
1.	*B.C. SOIL*	*20*	*1.38*	*15*	*1.46*
2.	*B.C. SOIL+ 10% FLY ASH*	*16*	*1.45*	*12*	*1.67*
3.	*B.C. SOIL +15% FLY ASH*	*15*	*1.49*	*10*	*1.69*
4.	*B.C. SOIL +20% FLY ASH*	*14*	*1.50*	*8*	*1.71*
5.	*B.C. SOIL +25% FLY ASH*	*12*	*1.61*	*10*	*1.70*
6.	*B.C. SOIL +30% FLY ASH*	*15*	*1.90*	*12*	*1.72*
7.	*B.C. SOIL+10% LIME*	*14*	*1.37*	*11*	*1.80*
8.	*B.C. SOIL+15% LIME*	*14*	*1.39*	*16*	*1.74*
9.	*B.C. SOIL+20% LIME*	*14*	*1.45*	*18*	*1.67*
10.	*B.C. SOIL+25% LIME*	*12*	*1.80*	*19*	*1.67*
11.	*B.C. SOIL+30% LIME*	*13*	*1.40*	*19*	*1.67*

B. Compaction Parameters:

Optimum Moisture Content (OMC) and Maximum dry Density (MDD) the compaction characteristics for Standard Proctor comp active effort for the black Cotton soil- fly ash mixes reveal that the MDD decreases and the OMC increase With increasing fly ash content. That is shown in fig.1 & fig.2.

The OMC variation with increasing fly ash content shown in figure 1

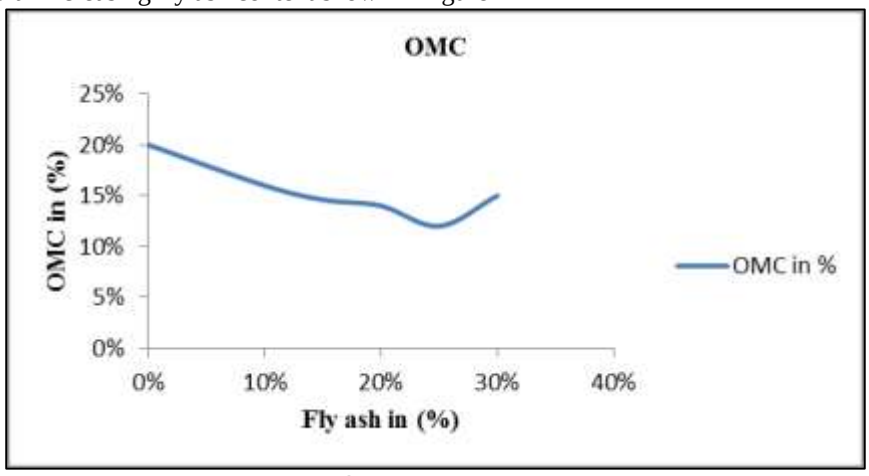

Fig. 5: Optimum moisture content

The MDD variation with increasing fly ash content shown in figure 2

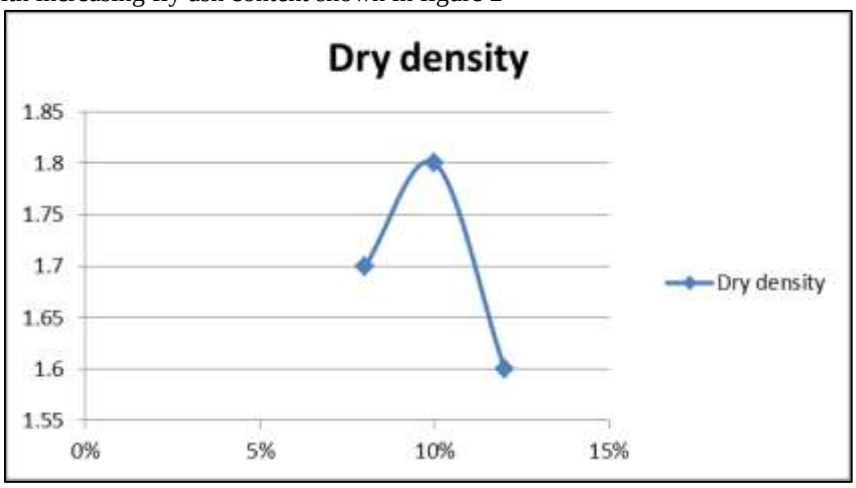

Fig. 6: Maximum dry density

Optimum Moisture Content (OMC) and Maximum dry Density (MDD) the compaction characteristics for Standard Proctor comp active effort for the black Cotton soil- lime mixes reveal that the MDD decreases and the OMC increase With increasing fly ash content. That is shown in fig.3 & fig.4.

The OMC variation with increasing lime content shown in figure 3

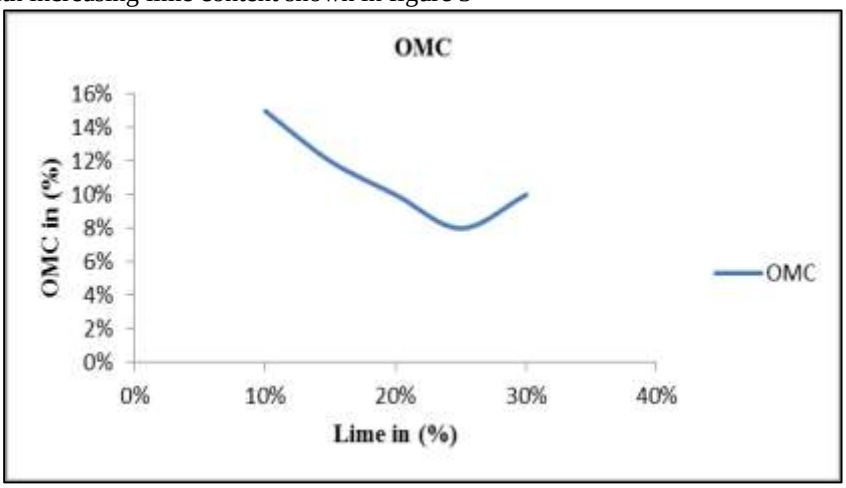

Fig. 7: Optimum moisture content

The MDD variation with increasing lime content shown in figure 4

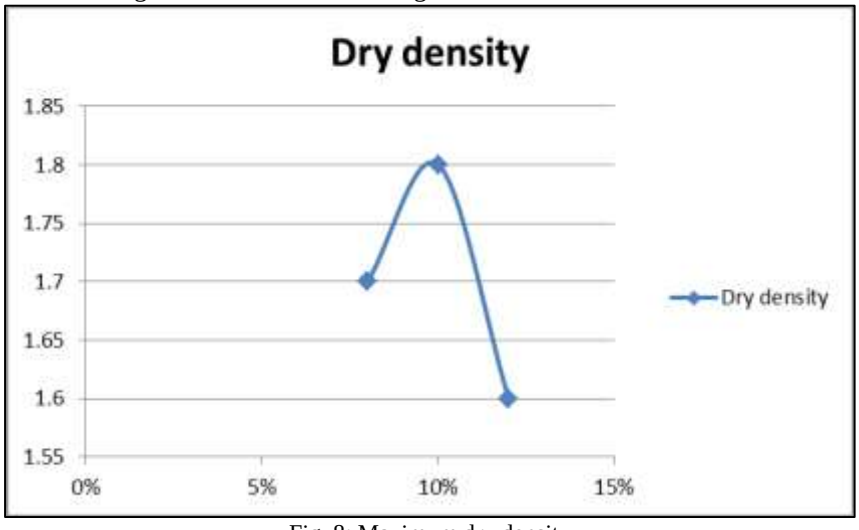

Fig. 8: Maximum dry density

Optimum Moisture Content (OMC) and Maximum Dry Density (MDD) the compaction characteristics for Modified Proctor comp active effort for the black Cotton soil- fly ash mixes reveal that the MDD decreases and the OMC increase with increasing fly ash content. That is shown in fig.5 & fig.6.

The OMC variation with increasing fly ash content shown in figure 5

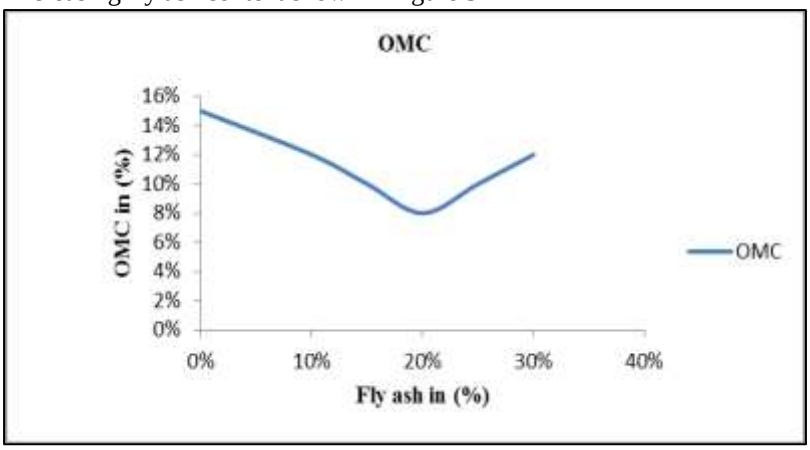

Fig. 9: Optimum moisture content

The MDD variation with increasing fly ash content shown in figure 6

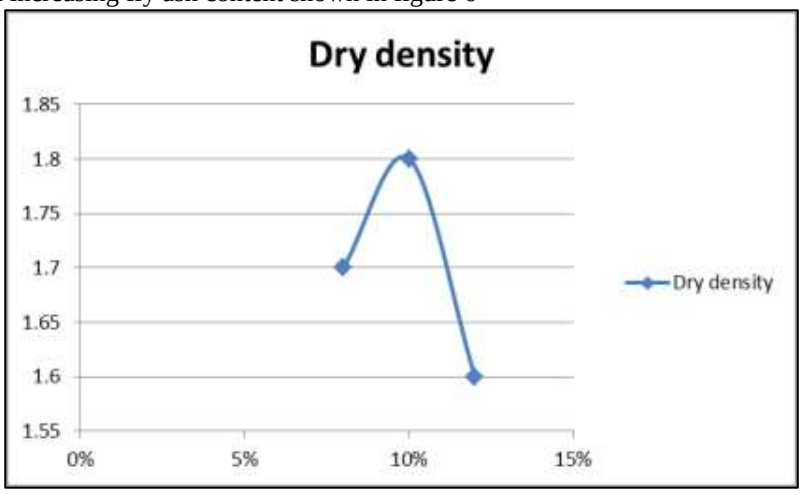

Fig. 10: Maximum dry density

Optimum Moisture Content (OMC) and Maximum Dry Density (MDD) the compaction characteristics for Modified Proctor comp active effort for the black Cotton soil- fly ash mixes reveal that the MDD decreases and the OMC increase With increasing fly ash content. That is shown in fig.7 & fig.8.

The OMC variation with increasing fly ash content shown in figure 7

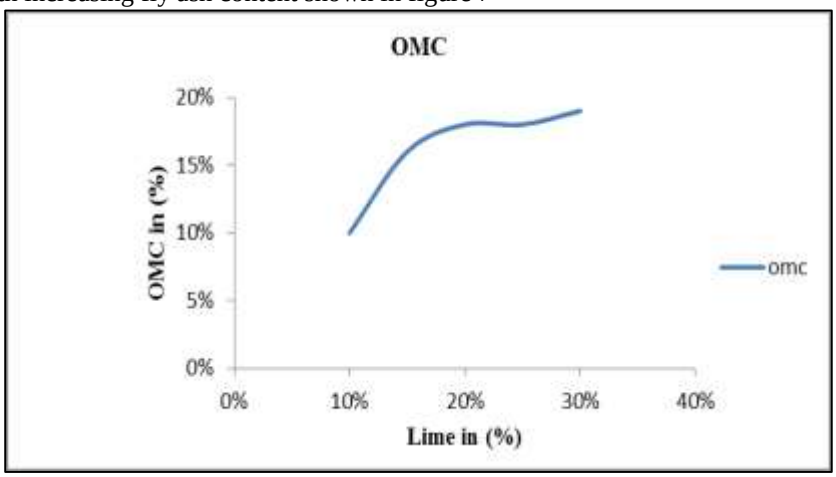

Fig. 11: Optimum Moisture Content

The MDD variation with increasing fly ash content shown in figure 8

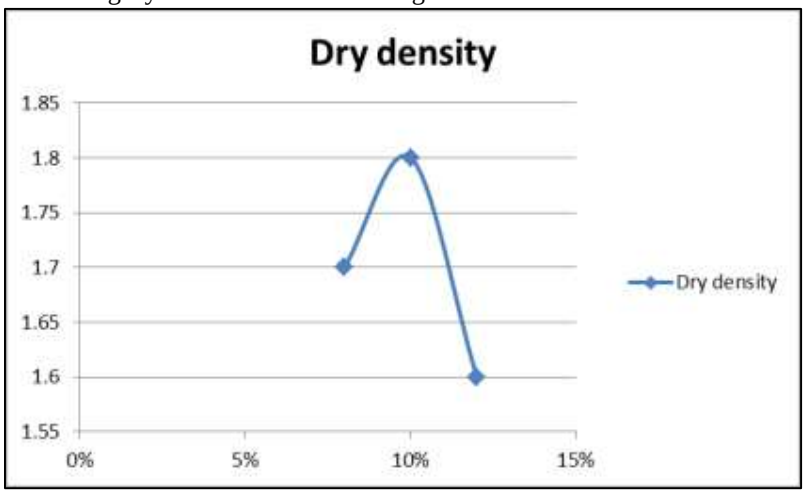

Fig. 12: Maximum dry density

VI. CONCLUSIONS

1) Fly ash, lime has been successfully used in the road construction industry
2) In this project work it has been found that the properties of black cotton soil get effectively modified by varying proportions of lime and fly ash.
3) It has been seen that liquid limit & plastic limit decreases by adding fly ash and lime up to 30 % & 30% respectively.
4) The optimum value of maximum dry density (compaction) was achieved for 30% Fly ash and 25% Lime.
5) 30% Fly ash and 25% lime was found to be the efficient input for stabilizing BC soil.
6) The performance with lime and fly ash stabilization for Black cotton soil shows better performance as indicated by reduction in annual maintenance cost per km road length.

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