Scientific Journal Impact Factor (SJIF) : 3.518
International Journal of Modern Trends in Engineering and Research
ISSN (ONLINE) : 2349 - 9745 ISSN (PRINT) : 2393 - 8161

Stabilization of Black cotton soil by using Fly ash and Lime

Darshitkumar R. Gohel[1], Sachin P. Jayaswal[2] and Nilesh S. Masne[3]
[1,2]UG Student, Department of Civil Engineering, Gokhale Education Society's R.H.Sapat College of Engineering,MS&R, Nashik-05, Maharashtra, India
[3]Assistant Professor, Department of Civil Engineering, Gokhale Education Society's R.H.Sapat College of Engineering,MS&R, Nashik-05, Maharashtra, India

Abstract— Stabilization of soil is important to enhance the engineering properties of expansive soil like strength, volume stability and durability. The Black cotton soils are very hard when dry, but lose its strength completely when in wet condition Expansive soils (black cotton soil) are a worldwide problem that poses several challenges for civil Engineers. In this work an attempt has been made to stabilize the soil using Fly ash and Lime. Experimental work has been carried out with 5%, 10%, and 15% of Fly ash as well 4 %, 8 % and 12% of lime content. The experimental work is based on different percentages of Fly ash and lime content in soil on tests for soil Liquid limit, Plastic limit, C.B.R. test, Unconfined Compression Test and Standard Proctor Test. The aim is to improve the engineering properties of the black cotton soil.

Keywords— Stabilization, Black cotton soil, Fly ash, Lime, Unconfined Compressive Strength, Liquid limit, Plastic limit, OMC, MDD, CBR.

I. INTRODUCTION

Expansive soil (Black cotton soil) is mostly found in the arid and semi-arid regions and it cover very large area of the world. It covers nearly 30% of the land in India and includes approximately the entire Deccan Plateau. Andhra Pradesh, Karnataka, Maharashtra, Parts of Gujarat and Western Madhya Pradesh. The name "Black Cotton" as an agricultural origin. Most of these soils are black in color and are good for growing Cotton. These soils can be used as a construction material when it possesses engineering properties such as high strength, low settlement and high durability. Difficulty is often experienced while working with such soils particularly in its field compaction. Black cotton soil experiences volumetric changes due to changes in water content and suction.

Black cotton soil is a type of expansive soil with high plasticity and can maintain water throughout the summer season. However swelling occurs during rainy seasons and shrinkage occurs on evaporation of water during summer seasons. Due to its peculiar characteristic of high plasticity, excessive swelling, shrinkage and low strength when wet, the soil is regarded unsuitable for construction material. Heavy financial investments are required to be made for construction of roads, canals and embankments due to non-availability of suitable soil.

However in developing country like India, due to industrial development there is increase in a demand for energy which has resulted in construction of considerable thermal power plants. At the moment there are total 87 working thermal power plants in India. This development has resulted in production of by-product like fly ash in large quantity. The disposal of fly ash requires large holding ponds, lagoons, landfills etc. Utilization of such hazardous by-product is very important to prevent the environment from its effect. Though fly ash has little cementatious value but in the presence of moisture it reacts chemically and forms cementatious compounds and attributes to the improvement to the strength and compressibility characteristics of soils.

It has a long history of use as an engineering material and has been successfully employed in geotechnical engineering. Studies have been conducted in the past by many investigators regarding the use of fly ash alone or in addition with lime for improving the properties of soils.

@IJMTER-2016, All rights Reserved

Hence it is important to study the Stabilization of black cotton soil by using Fly ash and lime as stabilizers and on the engineering properties of black cotton soil stabilized with fly ash-lime.

II. MATERIALS USED

2.1 Characteristics of the Experimental Soil

Locally available soil was used for the experimental investigation. Natural black cotton soil was obtained from Nasik district in Maharashtra state. The soil was excavated from a depth of 1.5 m from the natural ground level. The soil is dark brown to black in color. The obtained soil was air dried, pulverized manually and passing through 425 micron IS sieve was used. Different experiments were conducted to characterize the soil.

Table 1- Properties of experimental black cotton soil

Sr. no.	Parameter	Values
1	Specific gravity (Gs)	2.6
2	Liquid limit (LL)	65%
3	Plastic limit (PL)	43.58%
4	Shrinkage limit (Ws)	12.35%
5	Plasticity index (Ip)	21
6	MDD	1.627 gm/cc
7	OMC	19.20 %
8	Swelling index	37%
9	C.B.R(unsoaked)	22.95%

2.2 Chemical Properties of experimental fly ash

Fly ash for the present investigation was collected from the coal based thermal power plant located in Eklahare, Nasik district. It was collected in dry form from the hoppers and transported in air tight double polythene bags. The chemical properties of fly ash are given in table 2.

Table 2 - Physical & Chemical Properties of Experimental Fly Ash

Sr. No.	Chemical Properties	Unit	% by mass
1.	Silica(SiO_2)	%	58.66
2.	Magnesia(MgO)	%	1.82
3.	SO_3	%	0.76
4.	Na_2O	%	0.62
5.	SiO_2+AL_2O_3+Fe_2O_3	%	92.56
6.	Total chloride	%	0.027
7.	Loss on ignition	%	1.94
8.	Moisture content	%	0.25
9.	Specific gravity	-	2.23

2.3 Chemical composition of Lime

The Lime used as stabilizing agent was procured in 25 kg bag from a reputable chemical store and stored in a cool and dry place away from whether effects.

Table 3 - Physical & Chemical Properties of Lime

Sr. No.	Constituents	% Dry
1	Calcium Hydroxide, $Ca(OH)_2$	>88%
2	Magnesium Oxide,MgO	<0.8%
3	Iron Oxide, Fe_2O_3	<0.3%
4	Aluminum Oxide, AL_2O_3	0.4-0.8%
5	Silicon Dioxide, SiO_2	<1.3%
6	Loss on ignition	<26%
7	Acid insoluble	<3%
8	Specific gravity	2.2
9	Bulk density	450–500 kg/m3

III. EXPERIMENTAL PROCEDURE

The black cotton soil passing through 4.75 mm IS sieve was mixed in dry state with different percentage of fly ash+lime on weight basis. The required amount of water was added to the black cotton soil+fly ash+lime mix to carryout standard proctor test. Immediately after addition of water, the compaction was carried out without any delay to get compaction characteristics of the soil+fly ash+lime mix for the given percentages of the admixtures. After getting the compaction curve, maximum dry density and corresponding optimum moisture content was obtained for the given soil+fly ash+lime mix. The predetermined amount of water was added to the mix to achieve the water content of the mix equal to the optimum moisture content for the mix. Then this wet mix was left undisturbed for a period of 24 hrs. During this period of time care was taken to avoid the evaporation loss of water. After the required period of time delay the specimens were tested for MDD (Maximum Dry Density) and UCS (Unconfined Compressive Strength) by applying standard proctor test.

IV. EXPERIMENTAL PROGRAMME

Table 4 gives the details of testing programed and different mixtures of soil, fly ash and lime used in the present investigation. In the mix designation, the fly ash content is indicated by numerals. Thus 05 FA indicates that 05% by weight is fly ash and the remaining is soil and BCS stands for black cotton soil.

Table 4- Testing programed

Sr. no.	Designation of mix	Soil+fly ash mixture	% of Lime used
1	BCS	Black cotton soil only	Nil
2	05 FA	95% Soil+05% Fly ash	0,4,8,12
3	10 FA	90% Soil+10% Fly ash	0,4,8,12
4	15 FA	85% Soil+15% Fly ash	0,4,8,12

@IJMTER-2016, All rights Reserved

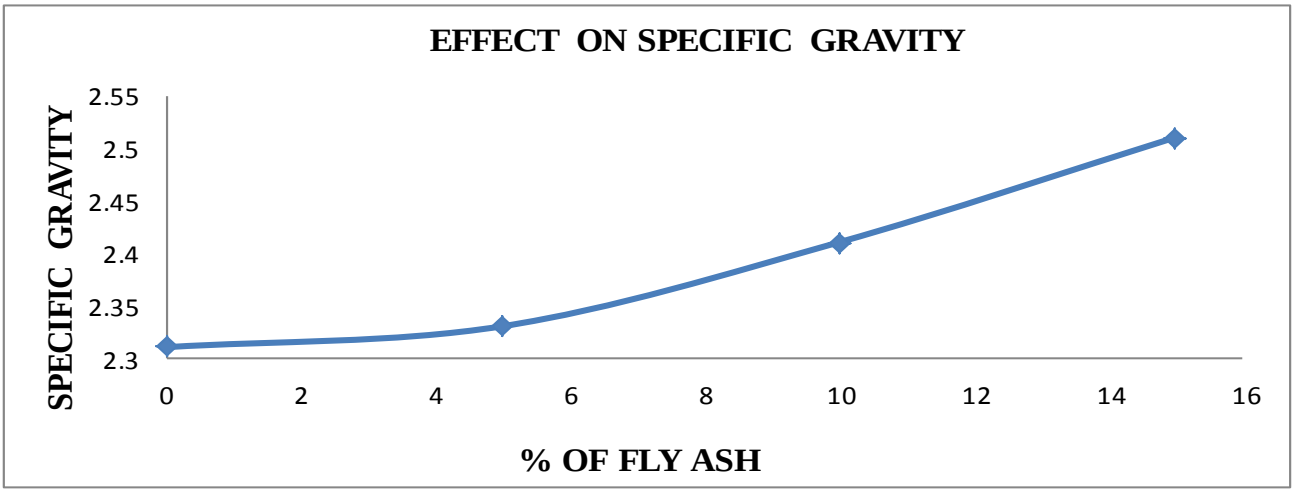
V. RESULTS AND DISCUSSIONS

5.1.1 Black cotton soil + Fly Ash (Index Properties)

Table 5 – Showing Index properties of BCS + Fly Ash

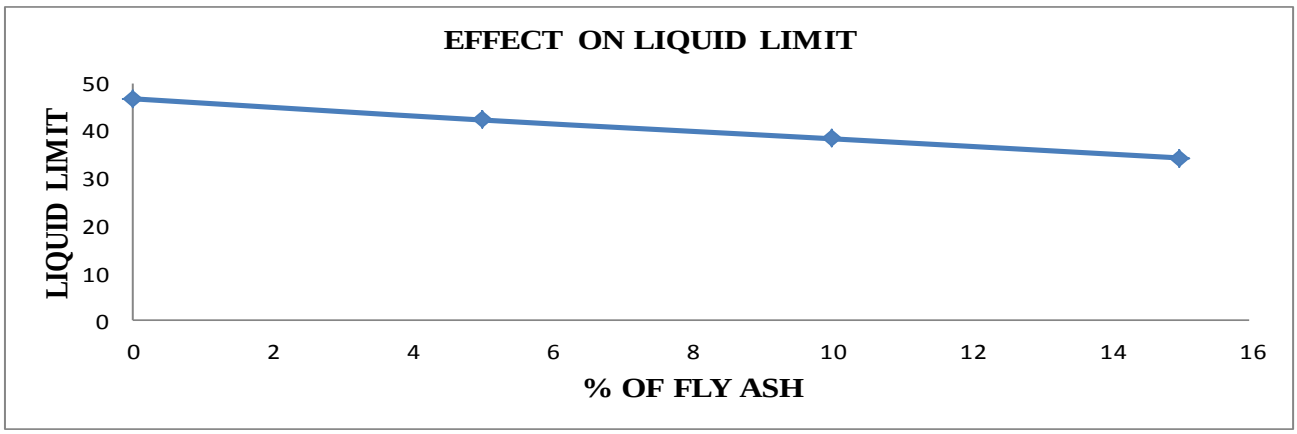
Sr. No.	Mixture	Sp. Gravity	Liquid limit %	Plastic limit %	Free swell index
1	Black cotton soil	2.31	46.66	55.22	62.48
2	BCS + 5% Fly Ash	2.33	42.18	41.61	54.13
3	BCS + 10% Fly Ash	2.41	38.23	39.49	49.18
4	BCS + 15% Fly Ash	2.51	34.17	35.31	42.41

Graph 1 shows the effect on Specific Gravity due to addition of different % of Fly Ash. From graph it can be observed Specific Gravity increases with increase in % of fly ash. The addition of 0%, 5%, 10% and 15% of Fly Ash increases the Specific Gravity from 2.31 to 2.33, 2.41 and 2.51 respectively.



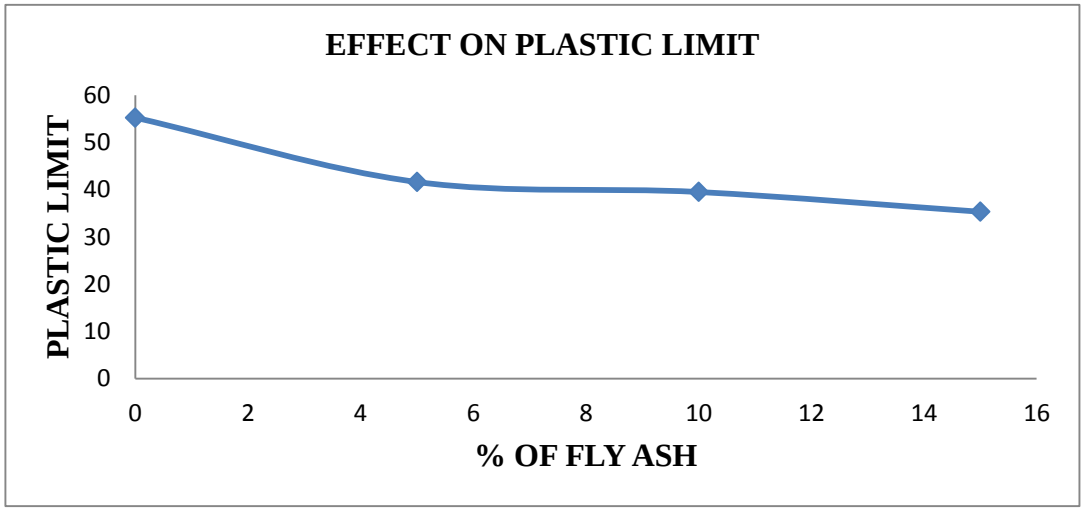
Graph 1: Variation in values of Specific Gravity as per increase in % of Fly Ash

Graph 2 shows the effect on Liquid Limit due to addition of different % of Fly Ash. From graph it can be observed Liquid Limit decreases with increase in % of fly ash. The addition of 0%, 5%, 10% and 15% of Fly Ash decreases the Liquid Limit from 46.66% to 42.18%, 38.23% and 34.17% respectively.



Graph 2: Variation in values of Liquid Limit as per increase in % of Fly Ash

Graph 3 shows the effect on Plastic Limit due to addition of different % of Fly Ash. From graph it can be observed Plastic Limit decreases with increase in % of fly ash. The addition of 0%, 5%, 10% and 15% of Fly Ash decreases the Plastic Limit from 55.22% to 41.61%, 39.49% and 35.31% respectively.



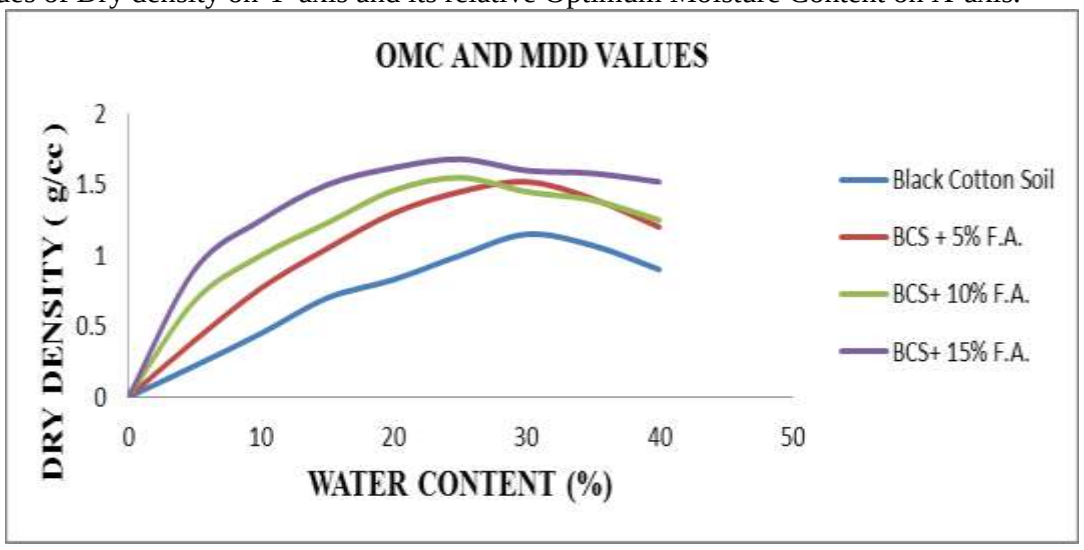
Graph 3: Variation in values of Plastic Limit as per increase in % of Fly Ash

5.1.2 Black cotton soil + Fly Ash (Engineering Properties)

Table 6 - Black Cotton Soil + Fly Ash (Engineering Properties)

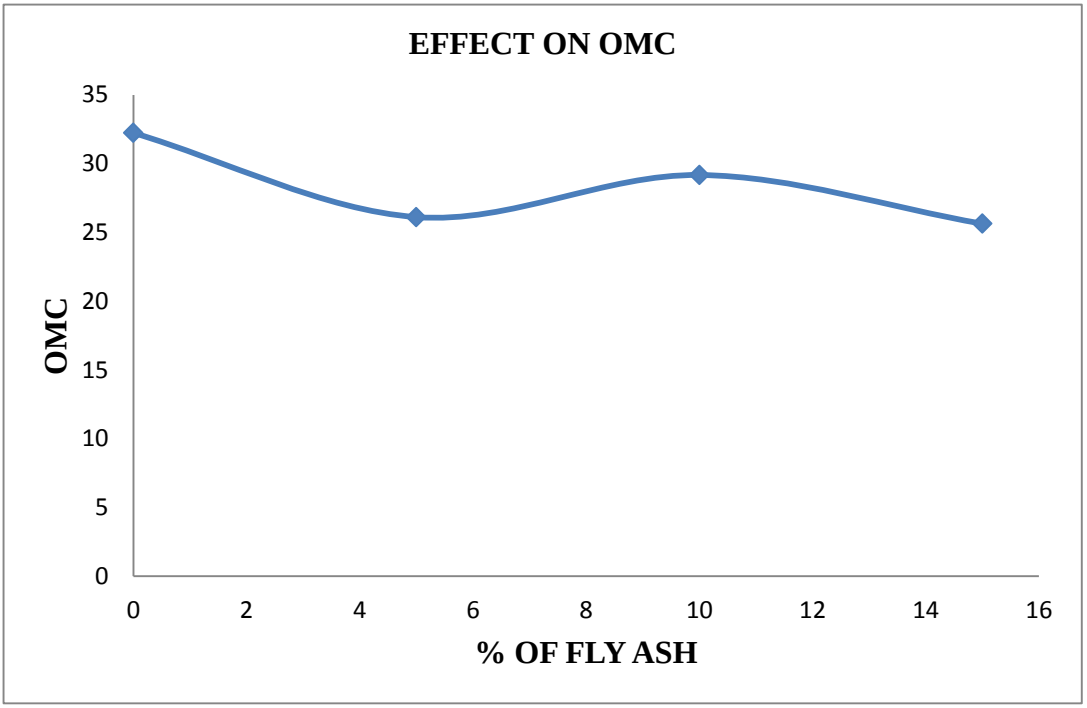
Sr. No.	Mixture	Standard Proctor		California Bearing Ratio	Unconfined Compression Strength kN/m^2
		O.M.C. (%)	M.D.D. (g/cc)		
1	Black Cotton Soil	32.23	1.12	6.98	71.35
2	BCS + 5% Fly Ash	26.11	1.49	7.83	73.58
3	BCS + 10% Fly Ash	29.17	1.53	12.78	78.80
4	BCS + 15% Fly Ash	25.63	1.68	17.89	81.39

The values of Maximum Dry Density and Optimum Moisture content are obtained by taking the peak values of Dry density on Y-axis and its relative Optimum Moisture Content on X-axis.



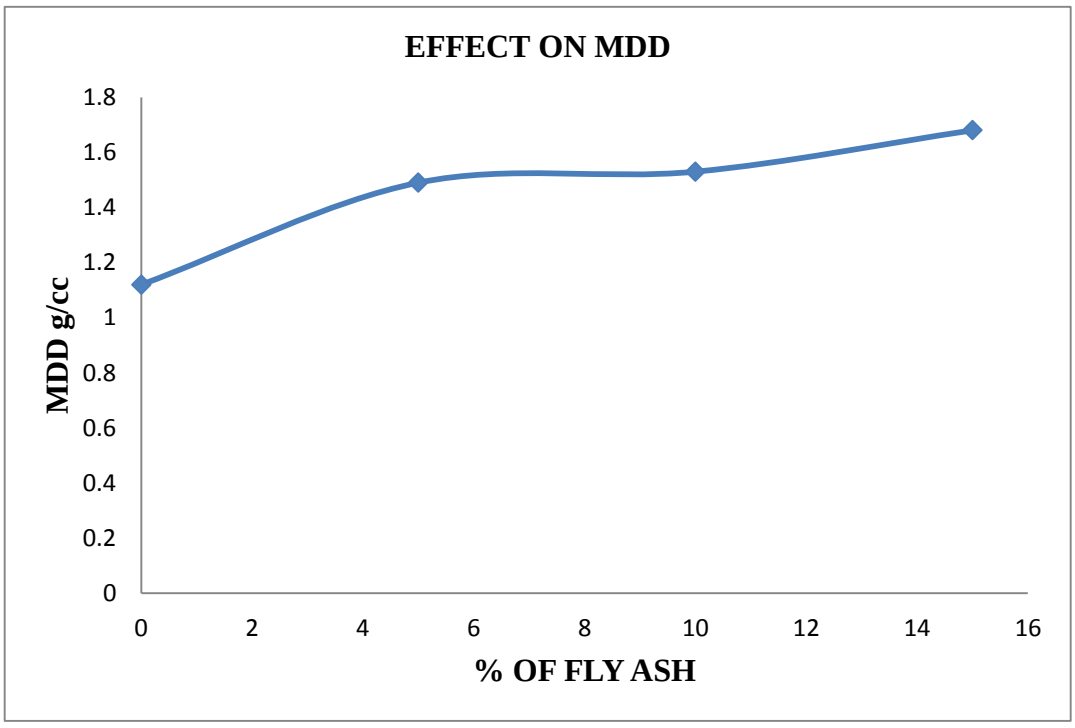
Graph 4: OMC and MDD values for different % of Fly Ash

Graph 5 shows the effect on Optimum Moisture Content due to addition of different % of Fly Ash. From the graph it is clear that the OMC values decreases with the increase in % of Fly Ash. The OMC values decreased from 32.23% to 26.11%, 29.17% and 25.63% with addition of 0%, 5%, 10% and 15% of Fly Ash respectively.



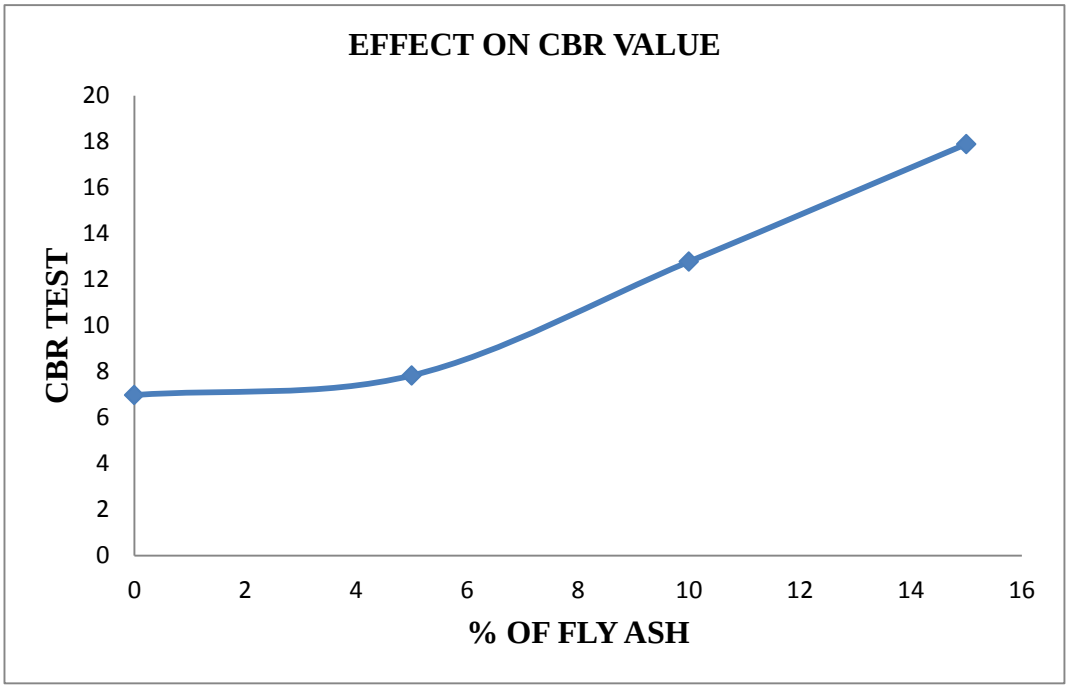
Graph 5: Variation in values of Optimum Moisture Content as per increase in % of Fly Ash

Graph 6 shows the effect on Maximum Dry Density due to addition of different % of Fly Ash. From the graph it is clear that the MDD values increases with the increase in % of Fly Ash. The MDD values increased from 1.12 gm/cc to 1.49 gm/cc, 1.53 gm/cc and 1.68 gm/cc with addition of 0%, 5%, 10% and 15% of Fly Ash respectively.



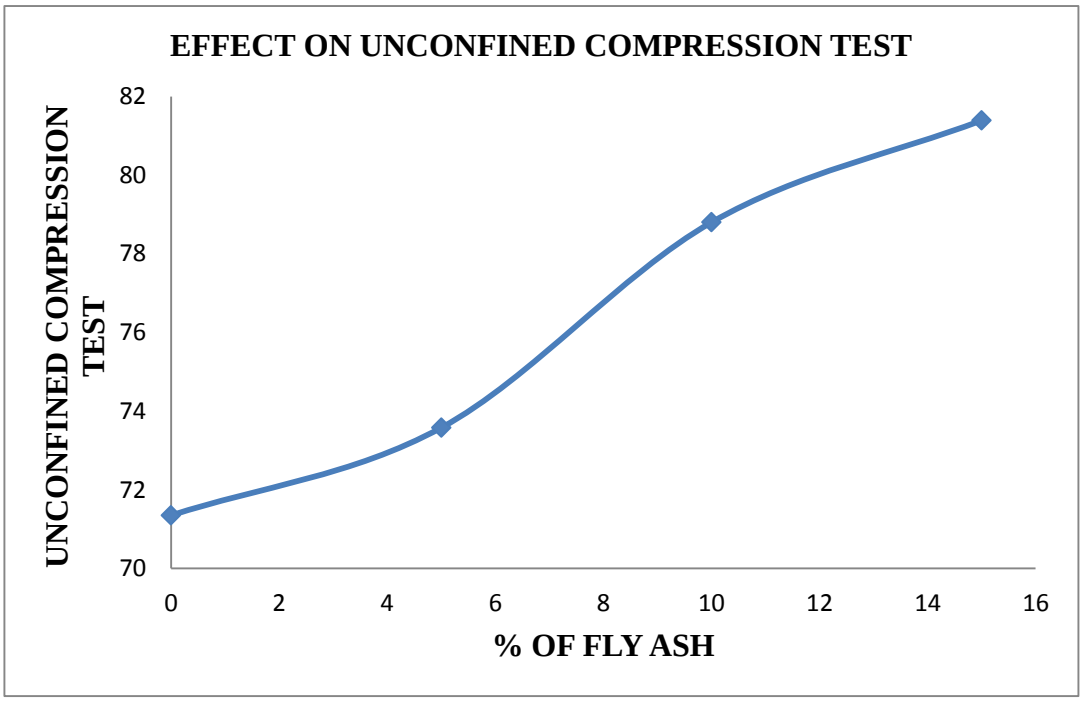
Graph 6: Variation in values of Maximum Dry Density as per increase in % of Fly Ash

Graph 7 shows the effect on California Bearing Ratio due to addition of different % of Fly Ash. From the graph it is clear that the CBR values increases with the increase in % of Fly Ash. The CBR values increased from 6.98 to 7.83, 12.78 and 17.89 with addition of 0%, 5%, 10% and 15% of Fly Ash respectively



Graph 7: Variation in values of California Bearing Ratio as per increase in % of Fly Ash

Graph 8 shows the effect on Compressive Strength due to addition of different % of Fly Ash. From the graph it is clear that the Compressive Strength increases with the increase in % of Fly Ash. The Compressive Strength increased from 71.35kN/m^2 to 73.58kN/m^2, 78.80kN/m^2 and 81.39kN/m^2 with addition of 0%, 5%, 10% and 15% of Fly Ash respectively.



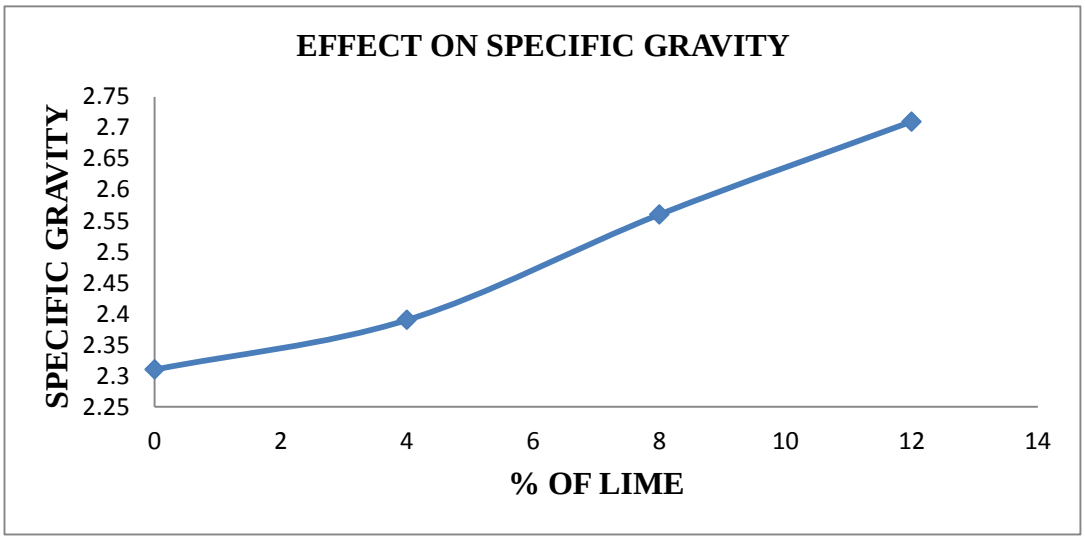
Graph 8: Variation in values of Compressive Strength as per increase in % of Fly Ash

5.1.3 Black cotton soil + Lime (Index Properties)

Table 7 – Showing Black cotton soil + Lime (Index Properties)

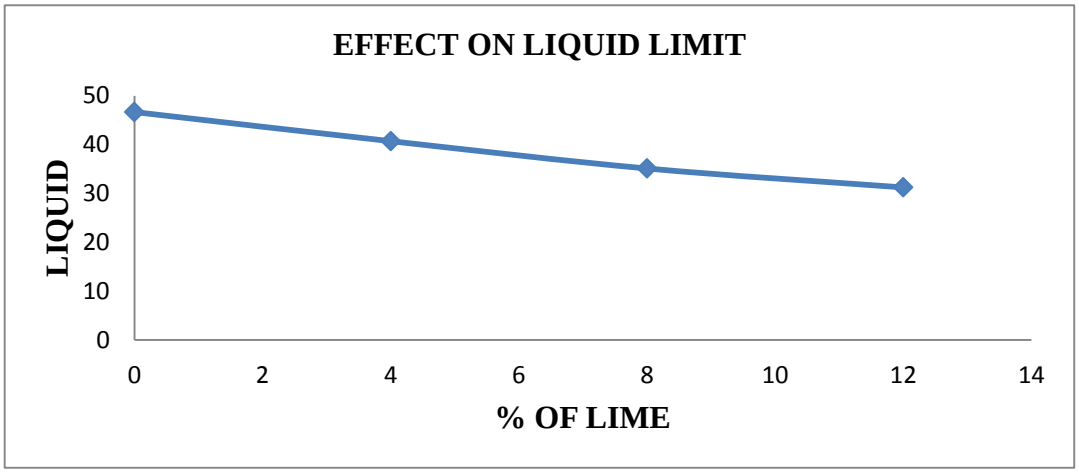
Sr. No.	Mixture	Sp. Gravity	Liquid limit %	Plastic limit %	Free swell index
1	Black cotton soil	2.31	46.66	55.22	62.48
2	BCS + 4% Lime	2.39	40.70	Non-Plastic	51.29
3	BCS + 8% Lime	2.56	35.11	Non-Plastic	46.97
4	BCS + 12% Lime	2.71	31.23	Non-Plastic	35.12

Graph 9 shows the effect on Specific Gravity due to addition of different % of Lime. From graph it can be observed Specific Gravity increases with increase in % of Lime. The addition of 0%, 4%, 8% and 12% of Lime increases the Specific Gravity from 2.31 to 2.39, 2.56 and 2.71 respectively.



Graph 9: Variation in values of Specific Gravity as per increase in % of Lime

Graph 10 shows the effect on Liquid Limit due to addition of different % of Lime. From graph it can be observed Liquid Limit decreases with increase in % of Lime. The addition of 0%, 4%, 8% and 12% of Lime decreases the Liquid Limit from 46.66% to 40.70%, 35.11% and 31.23% respectively.



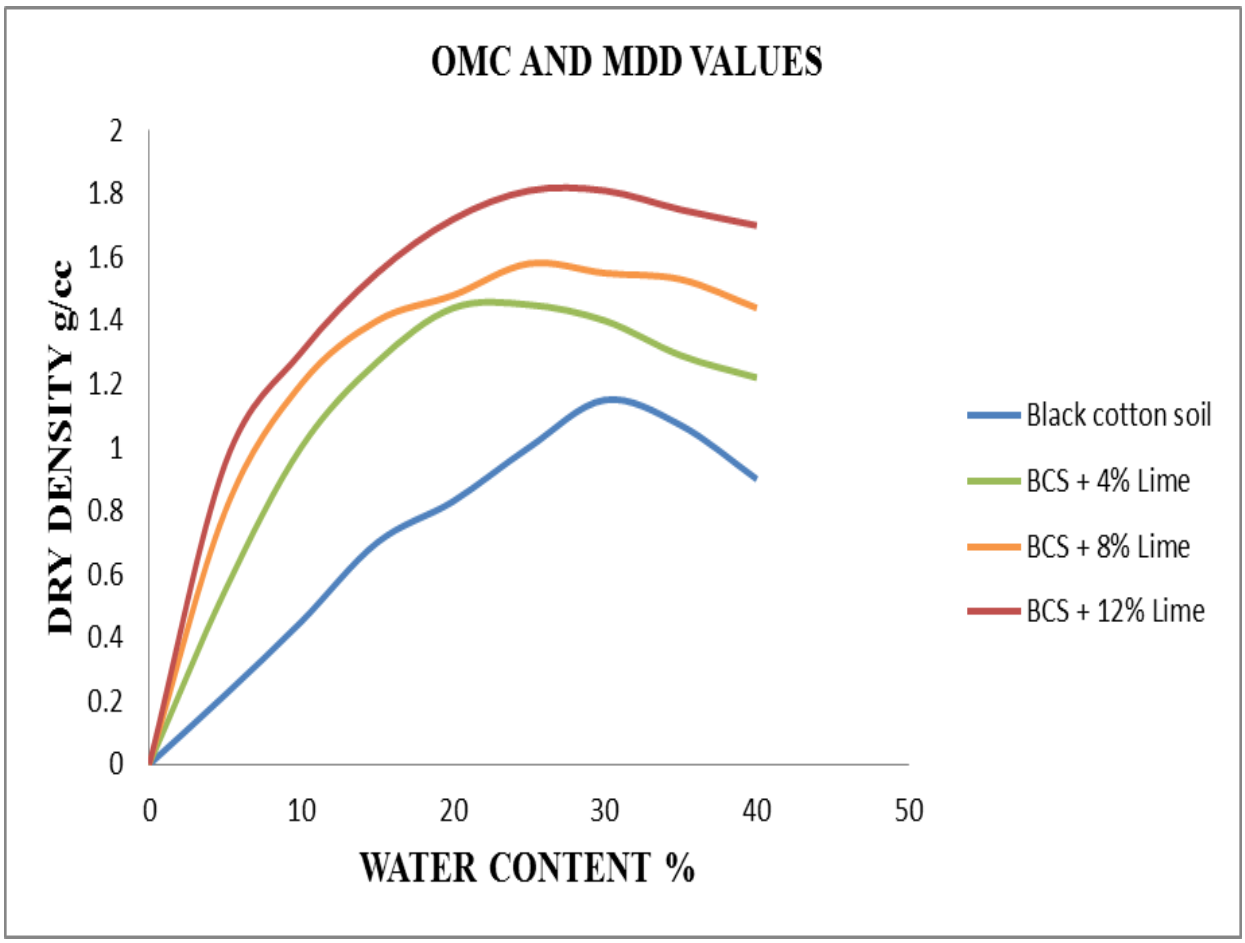
Graph 10: Variation in values of Liquid Limit as per increase in % of Lime

5.1.4 Black Cotton Soil + Lime (Engineering Properties)

Table 8 - Showing Black Cotton Soil + Lime (Engineering Properties)

Sr. No.	Mixture	Standard Proctor		California Bearing Ratio	Unconfined Compression Strength kN/m^2
		O.M.C. %	M.D.D. g/cc		
1	Black Cotton Soil	32.23	1.12	6.98	71.35
2	BCS + 4% Lime	23.29	1.53	8.1	78.12
3	BCS + 8% Lime	25.11	1.63	13.3	81.58
4	BCS + 12% Lime	22.89	1.69	18.72	83.53

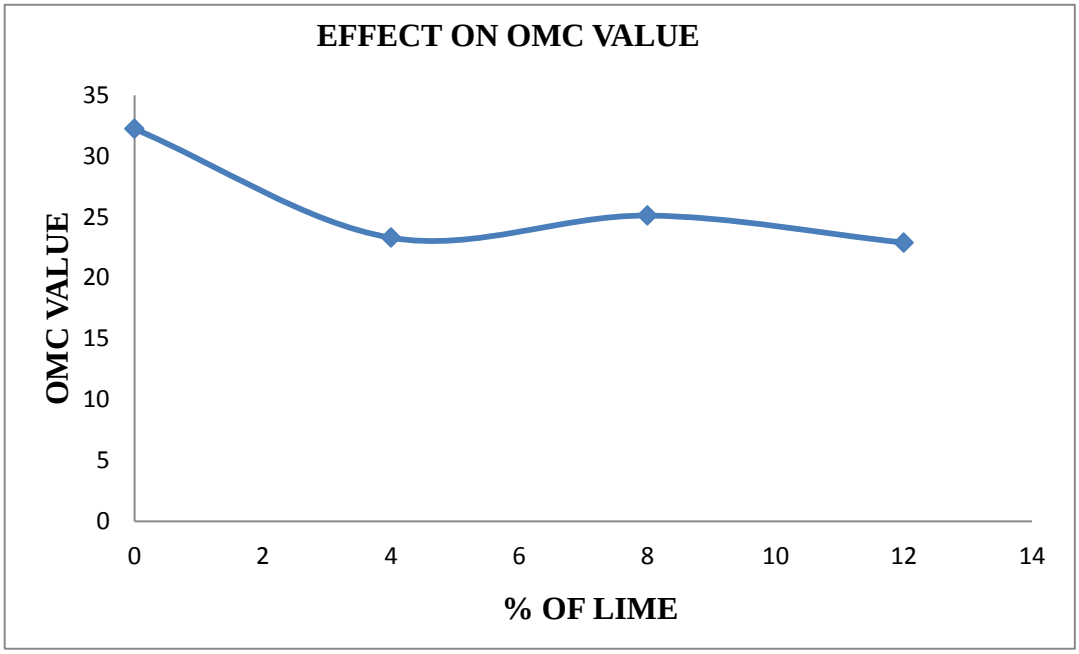
The values of Maximum Dry Density and Optimum Moisture content are obtained by taking the peak values of Dry density on Y-axis and its relative Optimum Moisture Content on X-axis.



Graph 11: OMC and MDD values for different % of Lime

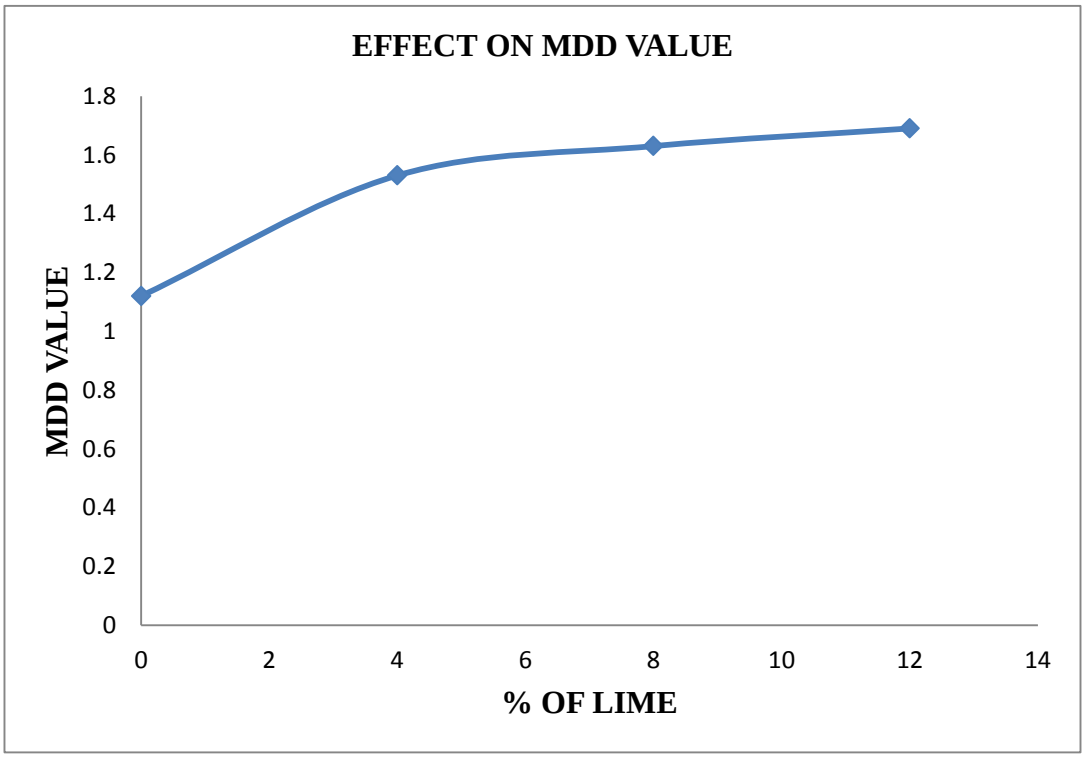
Graph 12 shows the effect on Optimum Moisture Content due to addition of different % of Lime. From the graph it is clear that the OMC values decreases with the increase in % of Lime. The OMC values decreased from 32.23% to 23.29%, 25.11% and 22.89% with addition of 0%, 4%, 8% and 12% of Lime respectively.

@IJMTER-2016, All rights Reserved



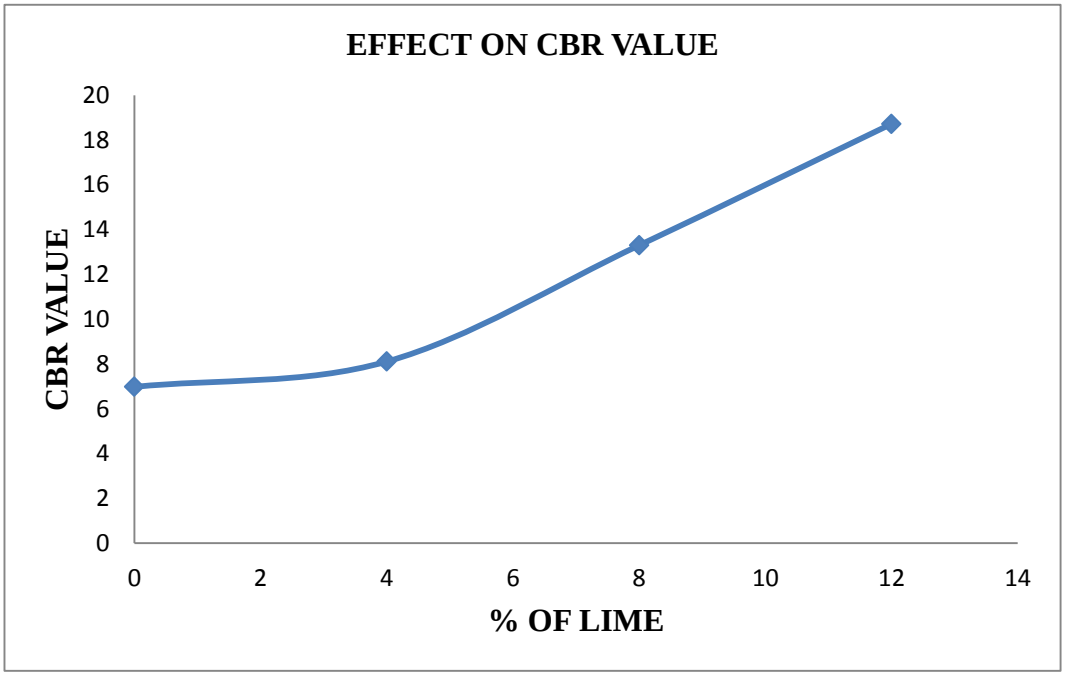
Graph 12: Variation in values of Optimum Moisture Content as per increase in % of Lime

Graph 13 shows the effect on Maximum Dry Density due to addition of different % of Lime. From the graph it is clear that the MDD values increases with the increase in % of Lime. The MDD values increased from 1.12 gm/cc to 1.53 gm/cc, 1.63 gm/cc and 1.69 gm/cc with addition of 0%, 4%, 8% and 12% of Lime respectively.



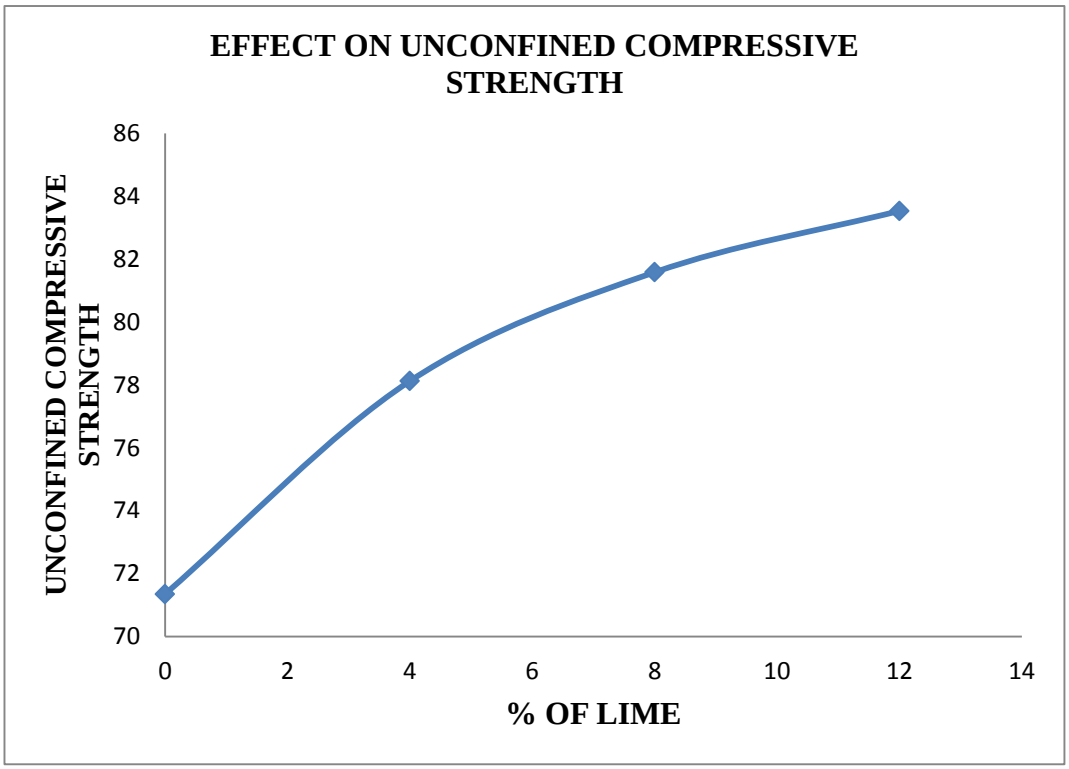
Graph 13: Variation in values of MDD as per increase in % of Lime

Graph 14 shows the effect on California Bearing Ratio due to addition of different % of Lime. From the graph it is clear that the CBR values increases with the increase in % of Lime. The CBR values increased from 6.98 to 8.10, 13.30 and 18.72 with addition of 0%, 4%, 8% and 12% of Lime respectively.



Graph 14: Variation in values of California Bearing Ratio as per increase in % of Lime

Graph 15 shows the effect on Compressive Strength due to addition of different % of Lime. From the graph it is clear that the Compressive Strength increases with the increase in % of Lime. The Compressive Strength increased from 71.35kN/m^2 to 78.12kN/m^2, 81.58kN/m^2 and 83.53kN/m^2 with addition of 0%, 4%, 8% and 12% of Lime respectively.



Graph 15: Variation in values of Compressive Strength as per increase in % of Lime

VI. CONCLUSIONS

The Following conclusions have been carried out from the above experimental work:

1. Liquid limit and plastic limit of BC soil decrease with increasing % fly ash. But Liquid limit and plastic limit of BC soil increase with increasing % lime.
2. Maximum dry density, unconfined compressive strength and California bearing ratio of black cotton soil increases with an increase in % of stabilizing materials.
3. With increase in % of addition of fly ash, maximum dry density starts increasing & optimum moisture content starts decreasing.
4. 15% addition of fly ash gives maximum value of unconfined compressive strength and California bearing ratio with increase in % of fly ash it starts decreasing.
5. With increase in % of lime from 0% to 12% as (4%, 8%, 12%) Maximum dry density, unconfined compressive strength and California bearing ratio of black cotton soil increases.
6. With increase in % of lime, maximum dry density starts increasing & optimum moisture content starts decreasing.
7. 12% addition of lime gives maximum value of unconfined compressive strength and California bearing ratio with increase in % of lime it starts decreasing.

VII. SCOPE OF FUTURE INVESTIGATION

1) Instead of the addition of above one stabilizing material, the Stabilization of black cotton soil can be done by using materials like bentonite, Plastic Wastes and cement or combination of all.
2) Geogrids can be used as reinforcing material to increase strength of black cotton soil.
3) Stabilization of black cotton soil also studied by using the addition of scrap & low cost materials which are highly intense to the environment.

REFERENCES

[1] S. Bhuvaneshwari, R. G. Robinson & S. R. Gandhi, "Stabilization of Expansive Soil Using Fly Ash", Fly Ash Utilization Programme (FAUP), Journal of Transportation Engineering, pp. 149-155, March 2005.
[2] J. M. Raut & Dr. S. P. Bajad, "Stabilization of Expansive Soil using Fly Ash and Murum", International Journal of Innovative Research and Science, Vol. 3, Issue July 2014.
[3] Ankit Singh Negi & Mohammed Faizan, "Soil stabilization using Lime", IJIRSET, pp. 2319-8753, Vol. 2, Issue 2, February 2013.Gyanen. Takhelmayum & Savitha A. L, "Laboratory Study on Soil Stabilization Using Fly ash Mixtures", International Journal of Engineering Science and Innovative Technology, ISSN: 2319-5967, Volume 2, Issue 1, January 2013.
[4] Ashish Mehta, Kanak Parate, "Stabilization of black cotton soil by Fly Ash", International Journal of Application or Innovation in Engineering & Management (IJAIEM), ISSN 2319 – 4847, Issue 2013.
[5] Sagar K. Sonawane & Hardik R. Gorani "Effect of Compaction Delay on the Properties of Black cotton Soil Treated with Fly ash & Lime" ,International Journal of Modern Trends in Engineering & Research(IJMTER), ISSN 2349-9745,Issue 2015.
[6] Dr.B.C.Punmia "Soil Mechanics and Foundation Engineering", Laxmi Publications.
[7] IS 1498 (1970): Classification and identification of soils for general engineering purposes.
[8] IS 2720-10 (1991):Methods of test for soils, Part 10:Determination of unconfined compressive strength
[9] IS 2720-16 (1987): Methods of test for soils, Part 16: Laboratory determination of CBR.
[10] IS 2720-2 (1973): Methods of test for soils, Part 2: Determination of water content.
[11] IS 2720-5 (1985): Methods of test for soils, Part 5: Determination of liquid and plastic limit.
[12] IS 2809 (1972): Glossary of terms and symbols relating to soil engineering.
[13] IS 9198 (1979): compaction rammer for soil testing.
[14] IS 9259 (1979): liquid limit apparatus for soils.
[15] IS 10074 (1982): compaction mould assembly for light and heavy compaction test for soils.

ACKNOWLEDGEMENT

Given an opportunity to express our deep sense of gratitude towards our guide **Prof. N.S. Masne** for his well-formulated and indispensable guidance in accomplishment of this work.

We are also thankful to **Prof. S.M. Kale** and **Prof. B.N. Harne** for their guidance regarding laboratory works. We are extremely thankful to all the faculty members who have contributed their valuable time in helping us to achieve success in the work.

We also humbly thankful to **Dr. Narhari D. Chaudhari**, Head, Department of civil Engineering and **Dr. P.C. Kulkarni**, Principal, G.E.S's R.H.Sapat College of Engineering, Management Studies and Research, Nashik, for their continuous support and guidance.

ABOOUT THE AUTHORS

Darshitkumar Rameshbhai Gohel, He is currently pursuing UG in Civil Engineering at Gokhale Education Society's R.H.Sapat College of Engineering, Management Studies & Research, Nashik-05, Maharashtra, India

Sachin Pyarelal Jayaswal, He is currently pursuing UG in Civil Engineering at Gokhale Education Society's R.H.Sapat College of Engineering, Management Studies & Research, Nashik-05, Maharashtra, India

Nilesh Shrikrishna Masne, He has completed his B.E.Civil From MIT, Aurangabad, Maharashtra, India and M.E. From C.O.E.T. Akola, Maharashtra, India, he is assistant professor at Gokhale Education Society's R.H.Sapat College of Engineering, Management Studies & Research, Nashik-05, Maharashtra, India,

@IJMTER-2016, All rights Reserved