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Stabilization of B.C. Soil by Using Chemicals and Fly Ash

Dhananjay B. Bawaskar[1], Dr. S. S. Koranne[2]
[1]*P.G.Student Department of Civil Engineering, Government Engineering College Aurangabad Maharashtra , India*
[2] *Associate Professor, Department of Civil Engineering, Government Engineering College Aurangabad, Maharashtra, India*

Abstract: ***Black cotton soils are very susceptible to detrimental volumetric changes with changes in moisture. This behaviour of soil is attributed to the presence of mineral montmorillonite which has an expanding lattice. Black cotton soils because of their specific physical and chemical make are subjected to volume changes. In many countries including India, these soils are so extensive that alteration of highway routes to avoid the material is virtually impossible. Various remedial measures like soil replacement, prewetting, moisture control, lime stabilization etc. have been practiced with varied degrees of success. Extensive research is going on to find the solutions to Black cotton soils. Recent investigations on chemical stabilisation revealed that electrolytes like Calcium Sulphate, Calcium Carbonate, Zinc Chloride can be used in place of conventionally used lime, due to their ability to supply adequate cations. Fly ash is a waste by product from thermal power plants consuming thousands hectors of precious land for its disposal and also causing severe health and environmental hazards. This work presents the results of an experimental program undertaken to investigate the effect of Calcium Sulphate, Calcium Carbonate, Zinc Chloride and fly ash at different percentages on properties of black cotton soil. Atterbergs Limit of subgrade soil effect of addition of Fly Ash and Chemicals on CBR ,MDD ,OMC, From the results it is observed that 2% of Zinc Chloride and 12% of Fly ash improves the properties of black cotton soil as compared to Calcium sulphate & Calcium Carbonate. The conclusion drawn from this investigation is that a combination of 2% of chemicals and 12% of fly ash is more effective in improving the properties of black cotton soil.***

Keywords: Fly Ash, Calcium Sulphate, Calcium Carbonate, Zinc Chloride, Black Cotton Soil*.*

I. INTRODUCTION

The wetting and drying process of a subgrade layer composed of black cotton soil result in failure of pavement in the form of settlement and cracking. Therefore prior to construction of a road on such sub-grade, it is important either to remove the existing soil or to improve the engineering properties of existing soil by stabilization. Replacing the existing soil might not be a feasible option, so the best available approach is to stabilize the soil with a suitable stabilizer. Soil is one of the principal materials of construction in soil embankments and in stabilized soil base and sub base courses. Various types of soil have various properties according to their availability in different strata. Thus, it is important to carry out basic soil tests on the soil for subgrade or embankments.

In present investigation black cotton soil is tested using important soil tests such as standard proctor test, California Besaring Ratio test and consistency limits. Soil compaction is an important phenomenon in highway construction as compacted subgrade improves the load supporting ability of pavement, in turn resulting in pavement thickness requirement. Thus, behaviour of soil subgrade materials could be considerably improved by adequate compaction under controlled conditions. Black cotton soil for the present study is obtained fromChowka , a village near Aurangabad. The basic tests like liquid limit, plastic limit, standard proctor test, California Bearing Ratio Test, are carried out on raw black cotton soil. The black cotton soil is stabilized using Fly ash, Calcium Sulphate, Calcium Carbonate & Zinc Chloride with different proportions. Fly ash is used in 0,3,6,9,12 percentages by dry weight of soil chemicals. are used in 0.5%,1%,1.5% and 2% by weight of the soil.

A. Properties of Black Cotton Soil used

For the study of the effect of Fly ash, Calcium Sulphate, Calcium Carbonate & Zinc Chloride on black cotton soil, the sample was collected from Chowka, Village near about 14 Km from Aurangabad city. The engineering properties of the soil are determined by carrying out the experiments in the soil engineering laboratory of Govt. College of Engineering, Aurangabad. The obtained results are shown in table 1.1.

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Table 1.1: Engineering Properties of soil

Sr. No.	Properties of Soil	Values
1	Liquid Limit	72
2	Plastic Limit	30
3	Plasticity Index	46
4	Maximum Dry Density M.D.D.	1.46 g/cm^3
5	Optimum Moisture Content OMC	25.40
6	California Bearing Ratio CBR	1.90
7	Unconfined Compressive Strength U.C.S.	49.630 Kpa

A Soil is termed as fine grained if more than 50% of Soil sample passes through No. 200 US sieve. Fine grained soils are subdivided into silt (M) and Clay (C) based on their liquid limit (W_1) and Plasticity Index (IP). The soil is classified according to a plasticity chart devised by Casagrande for the soil classification system. For above properties of soil, it is classified as (CH) clay with high plasticity.

B. Fly Ash

Fly ash required for present investigation is collected from thermal power station Elkhart, Nashik. Engineering and chemical properties for Indian ashes of various power plants tested at CRRI have been found to be favourable to construction of roads and embankments. The properties of ash depend primarily on type of coal and its pulverization, burning rate and temperature, method of collection etc. The significant properties of fly ash that must be considered when it is used for construction of road embankment are gradation, compaction characteristic, shear strength and permeability properties. Fly ash possesses a silty texture Engineering properties of fly ash are given in following table 1.2.

Table 1.2: Properties of Fly Ash

Sr. No.	Properties of Fly Ash	Values
1	Specific gravity	2.15
2	Liquid Limit	32
3	Plastic Limit	Non-Plastic
4	Maximum Dry Density MDD	1.38 g/cm^2
5	Optimum Moisture Content OMC	31
6	California Bearing Ratio CBR	5.4



Photograph 1.1: Fly Ash

Over a period of last ten years, the image of fly ash has completely been changed from a “Polluting Waste” to “Resource Material”. The economic worth of fly ash has been understood by the people.

C. Economy in use of fly ash

Utilization of fly ash in road work results in cutting the cost of construction by 10 to 20%. Typically, the cost of borrowed soil varies from about Rs.100 to 200 per meter. Fly ash is available free of cost at the power plant and hence only transportation cost, laying and rolling cost are there in case of fly ash. Hence, when fly ash is used as a fill material, the economy achieved is directly related to transportation cost of fly ash. If the lead distance is less, considerable savings in construction cost can be achieved.

Similarly, the use of fly ash in pavement construction results in significant savings due to savings in cost of road aggregates. If environmental degradation costs due to use of precious topsoil and aggregates from borrowed areas, quarry sources and loss of fertile agricultural land due to ash deposition etc. the actual savings achieved will be much higher and fly ash use will be justified even for lead distances up to say 100 Km.

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Photograph 1.2: Calcium Carbonate



Photograph 1.3: Calcium Sulphate



Photograph 1.4: Zinc Chloride

D. Need of Investigation

Soil is the basic material for road construction. When black cotton soil which is having poor engineering properties is encountered, a civil engineer has following options

1) Finding new site for construction
2) Redesign the structure
3) Removing poor soil and replace it
4) Improving the engineering properties of locally available soil

In developing countries like India, where industrial growth is very high and the disposal of waste is a problem, use of the waste for improving engineering properties of soil will be an eco-friendly and economical solution.

The black cotton soil consists of mainly clays mineral montmorillonite. Modification of black cotton soil by chemical admixture is a common method of stabilizing the soil. The Advantage of chemical stabilization is that it reduces swelling shrinking tendency of soil and also renders the soil less plastic. Calcium Sulphate, Calcium Carbonate, Zinc Chloride can be effectively used in place of conventionally used lime because of adequate supply of cation for ready cation exchange.

E. Objectives

Objectives of the study are

1) To study the effect of Zinc Chloride & fly ash with varying percentages on properties of black cotton soil.
2) To study the effect of Calcium Sulphate & fly ash with varying percentages on black cotton soil.
3) To study the effect of Calcium Carbonate & fly ash with varying percentages on black cotton soil.
4) To study the effect of fly ash along with these chemicals with varying percentages on black cotton soil.

F. Mix Properties

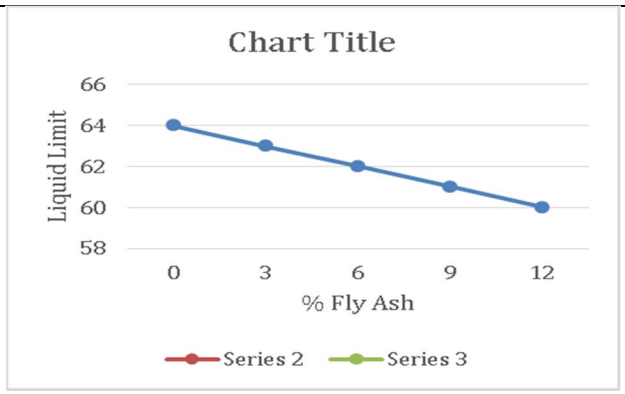
The black cotton soil is mixed with Calcium Carbonate and Fly ash as one set of proportions and Zinc Chloride and Fly ash as another set. The chemicals, Calcium Sulphate, Calcium Carbonate & Zinc Chloride are purchased from a chemical shop at Nashik.

The fly ash is added in proportions of 0%,3%,6% & 9% by weight of black cotton soil.

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Calcium Sulphate, Calcium Carbonate & Zinc Chloride added in proportion to 0.5%, 1%, 1.5%, and 2% by weight of soil.

% of soil	% of Fly Ash	Liquid Limit
100	0	64
97	3	63
94	6	62
91	9	61
88	12	60



The results of addition of fly ash have shown increase in strength and properties of soil. Hence it is used as a stabilizer in black cotton soil.

Earlier studies in stabilization of black cotton soil using such additives have shown increase in California Bearing Ratio, Optimum Moisture Content, Maximum Dry Density and Unconfined Compressive Strength. But these additives cannot be added in huge amounts, as they may absorb a significant portion of water added as the Optimum Moisture Content while performing the test.

Calcium Sulphate, Calcium Carbonate & Zinc Chloride solely cannot be used in the percentage of fly ash by weight of black cotton soil. The tests are conducted as per guidelines of I.S. Code.

The results of these tests and comparative study of both chemicals are discussed in the next chapter various graphs are plotted and results are discussed accordingly.

II. PERFORMANCE ANALYSIS

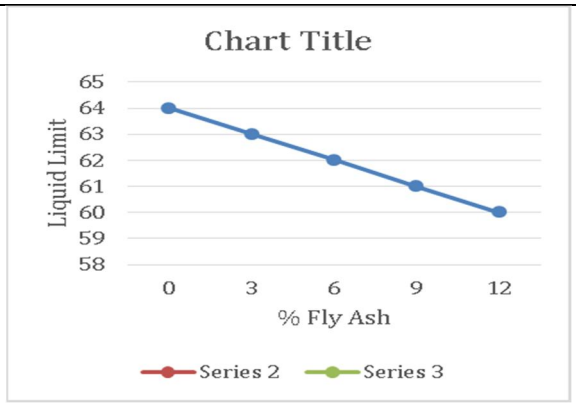
A. Experimental Analysis

For observation of effect of Fly ash and chemical additives Calcium Sulphate, Calcium Carbonate & Zinc Chloride on Black Cotton Soil. Following Engineering properties are determined by performing the experiment by adding these chemicals at different percentages with soil.

1) Liquid limit and plastic limit
2) Maximum Dry Density and optimum moisture content (MDD & OMC)
3) California Bearing Ratio (CBR)

Table 2.1: Effect of 2% Calcium Sulphate & Fly Ash on Liquid Limit

% of soil	% of $Caso_4$	% of Fly Ash	Liquid Limit
98	2.0%	0	64
95	2.0%	3	63
92	2.0%	6	62
89	2.0%	9	61
86	2.0%	12	60

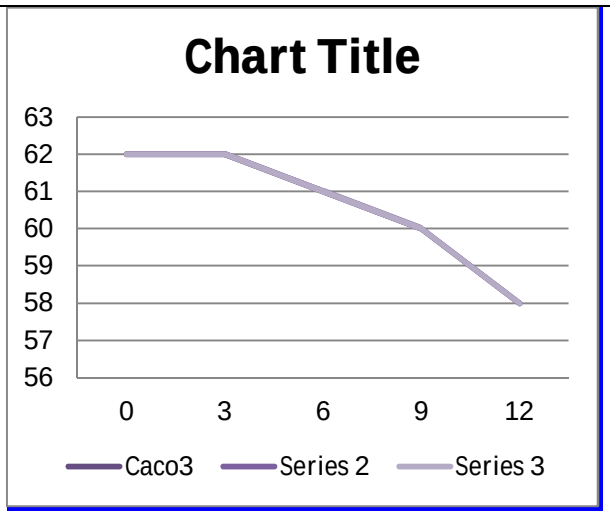


Graph 2.1: Variation of liquid limit for 2% Calcium Sulphatethe liquid limit reduces by.16.66 % Compaired with raw Black Cotton Soil.

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Table 2.2: Effect of 2% Calcium Carbonate & Fly Ash on Liquid Limit

% of Soil	% of $Caco_3$	% of Fly Ash	Liquid Limit
98	2.0%	0	62
95	2.0%	3	62
92	2.0%	6	61
89	2.0%	9	60
86	2.0%	12	58

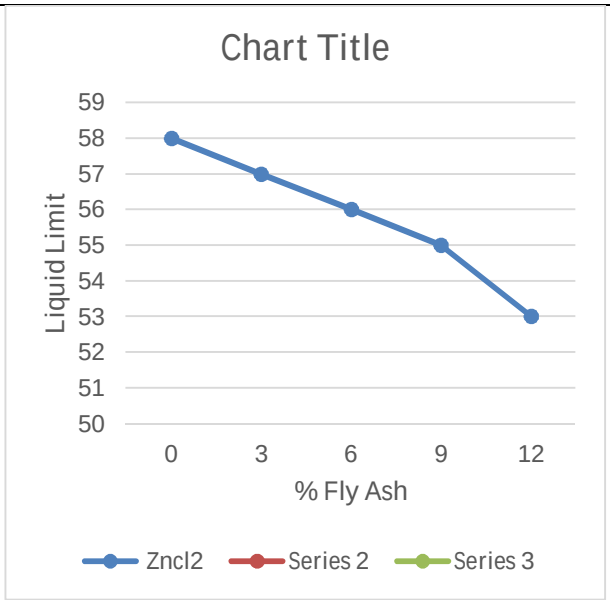


Graph 1.2: Effect of 2% Calcium Carbonate & Fly Ash on Liquid Limit

From the above graph it is seen that for 2% calcium carbonate, liquid limit decreases as the percentage of fly ash increases. For 12% fly ash the liquid limit reduces by 19.44 % Compared with raw Black Cotton Soil.

Table 2.3: Effect of 2% Zinc Chloride & Fly Ash on Liquid Limit

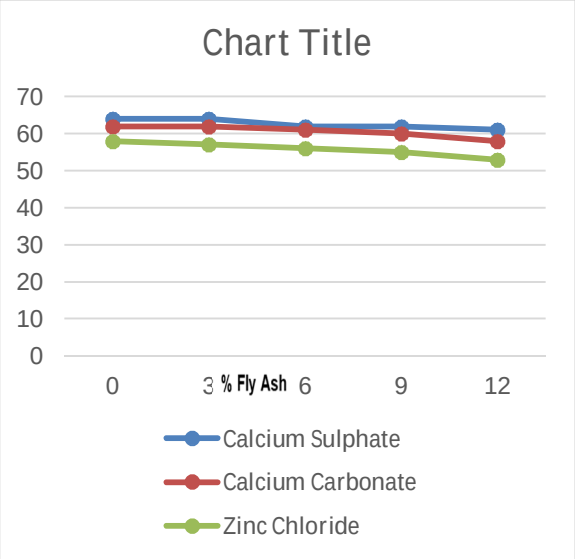
% of soil	% of $Zncl_2$	% of Fly Ash	Liquid Limit
98	2.0%	0	58
95	2.0%	3	57
92	2.0%	6	56
89	2.0%	9	55
86	2.0%	12	53



Graph 2.3: Effect of 2% Zinc Chloride & Fly Ash on Liquid Limit

From the above graph it is seen that for 2% Zinc chloride, liquid limit decreases as the percentage of fly ash increases. For 12% fly ash the liquid limit reduces by 26.38 % Compaired with raw Black Cotton Soil.

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Graph 2.4: Comparison of Liquid Limit for 2.00 % of Chemicals

From the above graph it is seen that the maximum decrease in liquid limit is observed for Zinc Chloride.

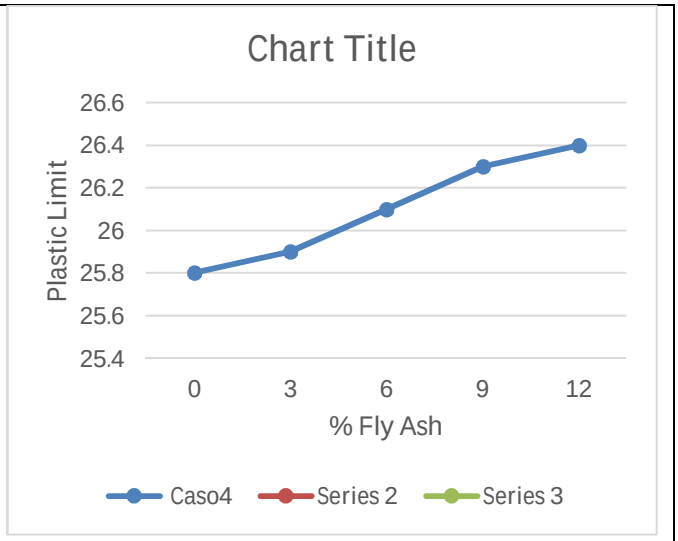
Graph 2.5: Comparison of Liquid Limit for 2% of Chemicals

From the tables above it is observed that the liquid limit of black cotton soil decreases as the percentage of chemical and fly ash increase. Maximum decrease in liquid limit for Zinc Chloride.

Black Cotton soil is observed with Chemical Zinc Chloride compared to other two chemicals *i.e.* Calcium Sulphate & Calcium Carbonate. The liquid limit changes from 58 to 53 for combination of 2% Zinc Chloride + 12% Fly Ash. .

Table 3.1: Effect of 2% Calcium Sulphate& Fly Ash on Plastic Limit

% of soil	% of $Zncl_2$	% of Fly Ash	Plastic Limit
98	2.0%	0	25.80
95	2.0%	3	25.90
92	2.0%	6	26.10
89	2.0%	9	26.30
86	2.0%	12	26.40



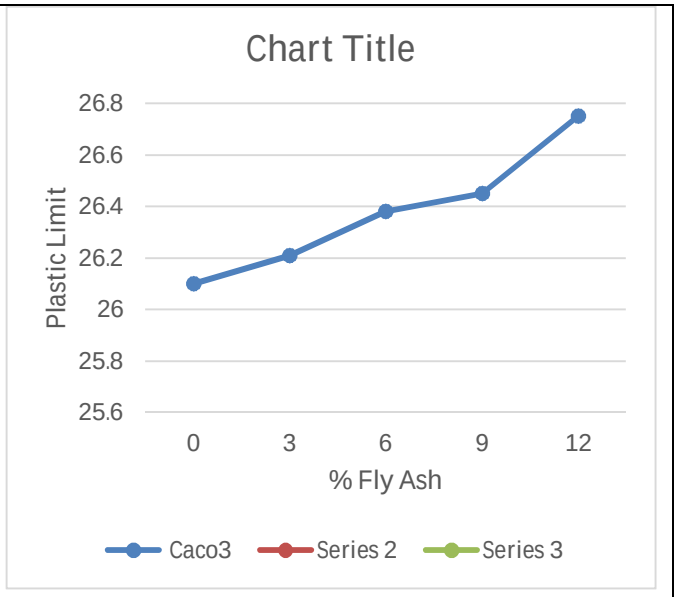
Graph 3.1: Variation of Plastic Limit for 2% Calcium Sulphate & Fly Ash

From the above graph it is seen that for 2% Calcium Sulphate plastic limit increases as the percentage of fly ash increases. For 12% fly ash plastic limit increases by 9.00 %Compaired with raw Black Cotton Soicl.

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Table 3.2: Effect of 2% Calcium Carbonate & Fly Ash on Plastic Limit

% of Soil	% of $Caco_3$	% of Fly Ash	Plastic Limit
98	2.0%	0	26.10
95	2.0%	3	26.21
92	2.0%	6	26.38
89	2.0%	9	26.45
86	2.0%	12	26.75

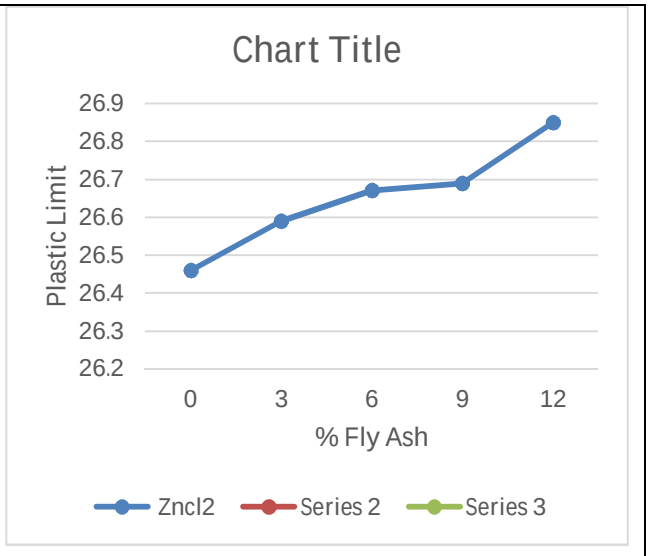


Graph 3.2: Variation of Plastic Limit for 2% Calcium Carbonate & Fly Ash

From the above graph it is seen that for 2% Calcium Carbonate, plastic limit increases as percentages of fly ash increases. For 12% fly ash, the plastic limit increases by 10.60%.Compaired with raw Black Cotton Soil.

Table 3.3: Effect of 2% Zinc Chloride & Fly Ash on Plastic Limit

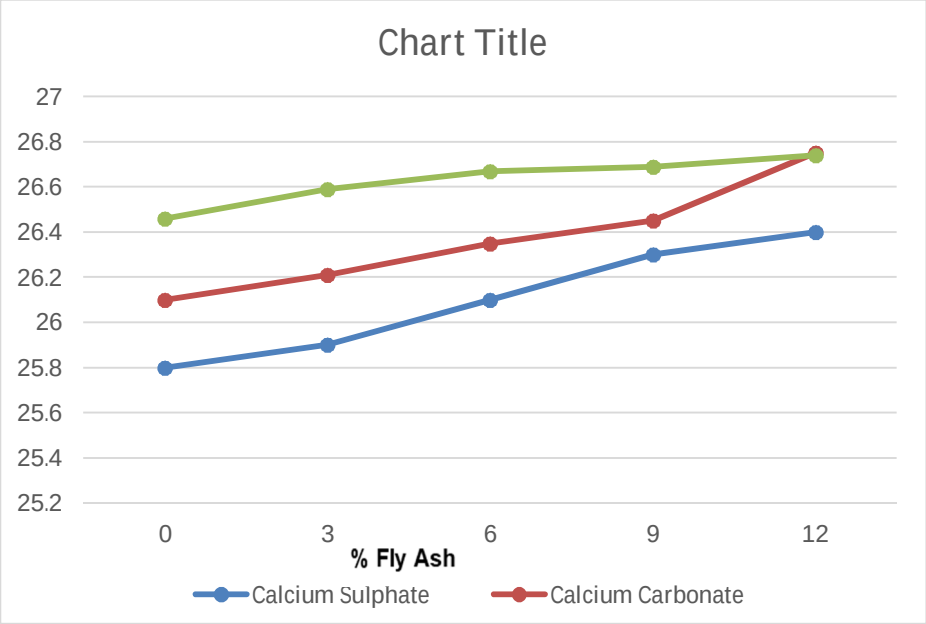
% of Soil	% of $Zncl_2$	% of Fly Ash	Plastic Limit
98	2.0%	0	26.46
95	2.0%	3	26.59
92	2.0%	6	26.67
89	2.0%	9	26.69
86	2.0%	12	26.85



Graph 3.3: Variation of Plastic Limit for 2% Zinc Chloride & Fly Ash

From the above graph, it is seen that, for 2% Zinc Chloride, Plastic Limit increases as the percentage of fly ash increases. For 12% fly ash, the plastic limit increases by 10.87 % Compaired with raw Black Cotton Soil.

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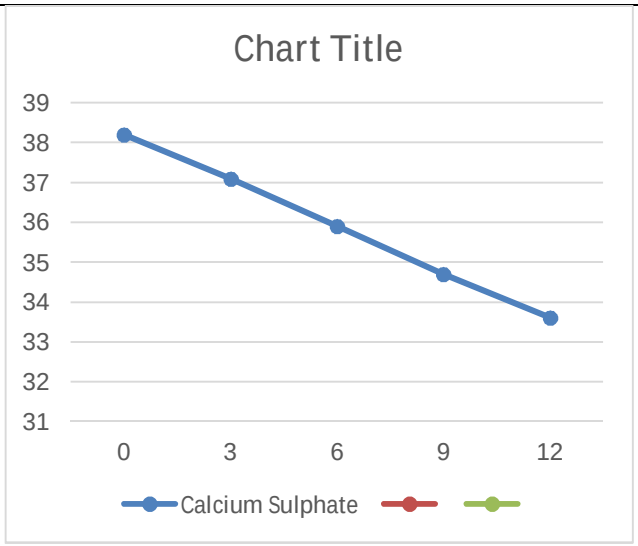


Graph 3.4: Comparison of Plastic Limit for 2% of Chemicals

From the above graph, it is seen that there is a nominal increase in plastic limit of black cotton soil. The maximum increase in plastic limit is observed for combination of 2% Zinc Chloride + 12% Fly Ash. The plastic limit increase from 26.46 to 26.85 for this combination. There is no significant change in plastic limit forThree chemicals.

Table 4.1: Effect of 2% Calcium Sulphate & Fly Ash on Plasticity Index

% of Soil	% of $CaSo_4$	% of Fly Ash	Plasticity Index
98	2.0%	0	38.20
95	2.0%	3	37.10
92	2.0%	6	35.90
89	2.0%	9	34.70
86	2.0%	12	33.60



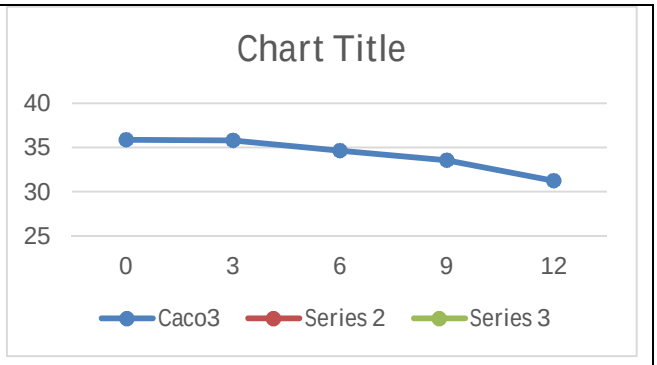
Graph 4.1: Variation of Plasticity Index for 2% Calcium Sulphate & Fly Ash

From the above graph it is seen that for 2% calcium sulphate plasticity index decreases the percentage of fly ash increases. For 12% fly ash plasticity index reduces by 28.91 % Compaired with raw Black Cotton Soil.

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Table 4.2: Effect of 2% Calcium Carbonate & Fly Ash on Plasticity Index

% of Soil	% of $Caco_3$	% of Fly Ash	Plasticity Index
98	2%	0	35.90
95	2%	3	35.79
92	2%	6	34.62
89	2%	9	33.55
86	2%	12	31.25

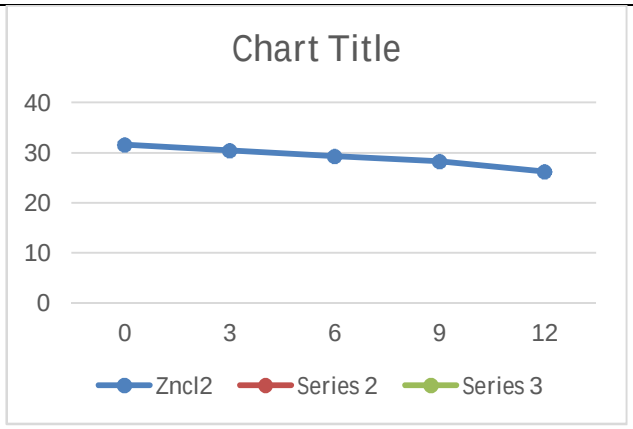


Graph 4.2: Variation of Plasticity Index for 2% Calcium Carbonate & Fly Ash

From the above graph, it is seen that, for 2% Calcium Carbonate, Plasticity Index decreases as the percentage of fly ash increases. For 12% fly ash, plasticity index reduces by 32.06 % Compaired with raw Black Cotton Soil.

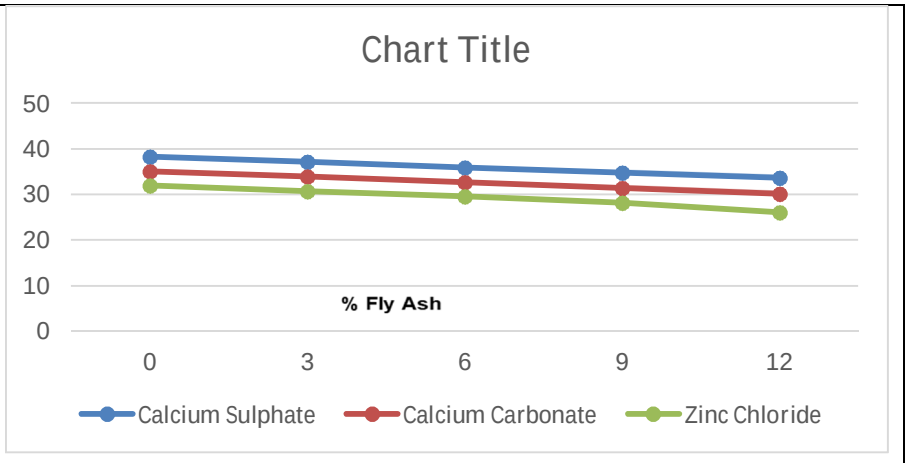
Table 4.3: Variation of 2% Zinc Chloride & Fly Ash on Plasticity Index

% of Soil	% of $Zncl_2$	% of Fly Ash	Plasticity Index
98	2.0%	0	31.54
95	2.0%	3	30.41
92	2.0%	6	29.33
89	2.0%	9	28.31
86	2.0%	12	26.26



Graph 4.3: Variation of Plasticity Index for 2% Zinc Chloride & Fly Ash

From the above graph, it is seen that, for 2% Zinc Chloride, plasticity index decreases as the percentage of fly ash increases. For 12% fly ash, plasticity index reduces by 42.91 % Compared with raw Black Cotton Soil.



Graph 4.5: Comparison of Plasticity Index for 2% of Chemicals

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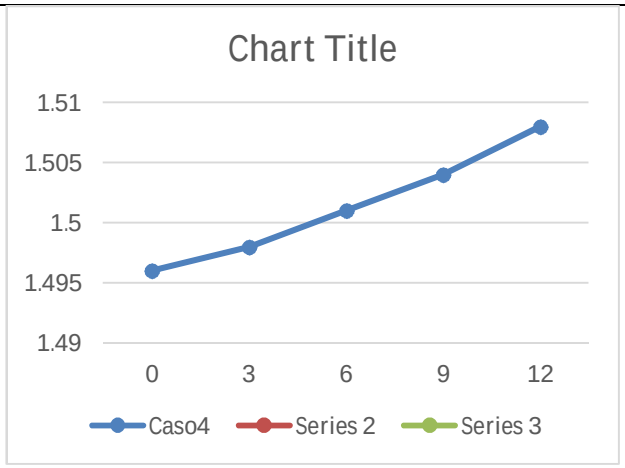
From the above graph, it is seen that the plasticity index reduces as the percentage of chemical increases. Maximum decrease in plasticity index is observed for Zinc Chloride.

From the above table it is observed that the increase in plastic limit and decrease in liquid limit cause a net reduction in plasticity index. The graph shows the variation of plasticity index with addition of chemicals to black cotton soil and fly ash. The plasticity index decreases as the percentage of fly ash increases. It is observed that the reduction in plasticity indices are 28.91%, 32.06% and 42.91% respectivelyForm the graph 4.5, it is observed that plasticity index decreases as the percentage of chemical increases similar trend is observed from the graph 4.1 & 4.4 for increase percentage of fly ash. The above result & trend in consistency limit indicates alteration of texture of soil from clayey to Silty..

B. Observations & Graphical Representation of Maximum Dry Density (MDD)

Table 5.1: Effect of 2.0% Calcium Sulphate & Fly Ash on Maximum Dry Density

% of Soil	% of $Caso_4$	% of Fly Ash	MDD g/cm^3
98	2%	0	1.496
95	2%	3	1.498
92	2%	6	1.501
89	2%	9	1.504
86	2%	12	1.508

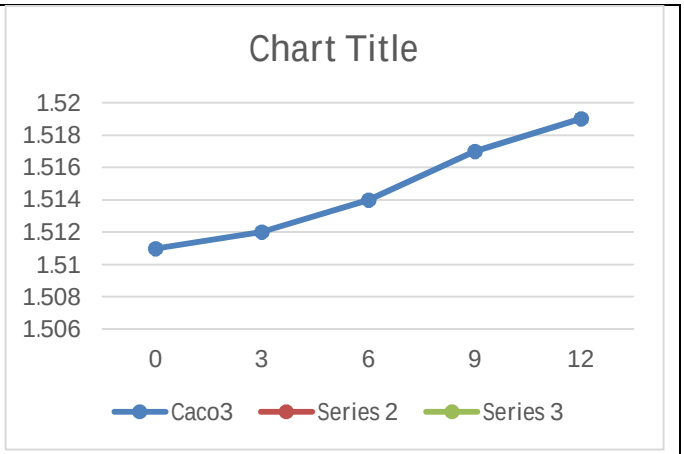


Graph 5.1: Variation of Maximum Dry density for 2% Calcium Sulphate & Fly Ash

From the above graph, it is seen that, for 2% Calcium Sulphate, the maximum dry density increases as the percentage of fly ash increases. For 12% fly ash, the maximum dry density increases by 3.28 %Compaired with raw Black Cotton Soil.

Table 5.2: Effect of 2% Calcium Carbonate & Fly Ash on Maximum Dry Density

% of Soil	% of $CaCo_3$	% of Fly Ash	MDD g/cm^3
98	2%	0	1.511
95	2%	3	1.512
92	2%	6	1.514
89	2%	9	1.517
86	2%	12	1.519



Graph 5.2: Variation of MDD for 2% Calcium Carbonate & Fly Ash

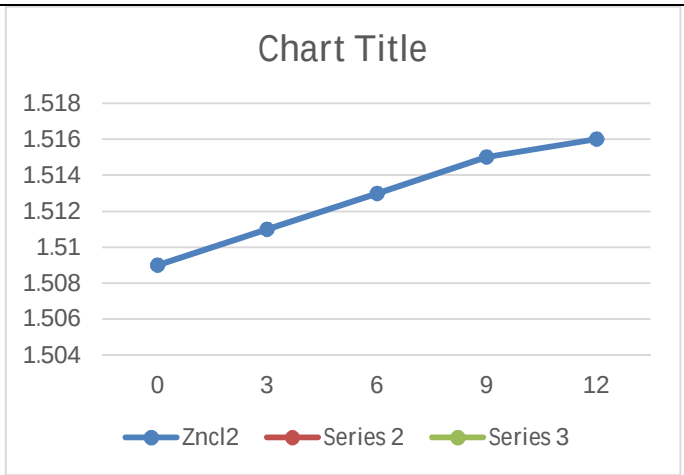
From the above graph, it is seen that, for 2% Calcium Carbonate, maximum dry density increases as the percentage of fly ash increases. For 12% fly ash the maximum dry density increases by 4.04 %Compared with raw Black Cotton Soil.

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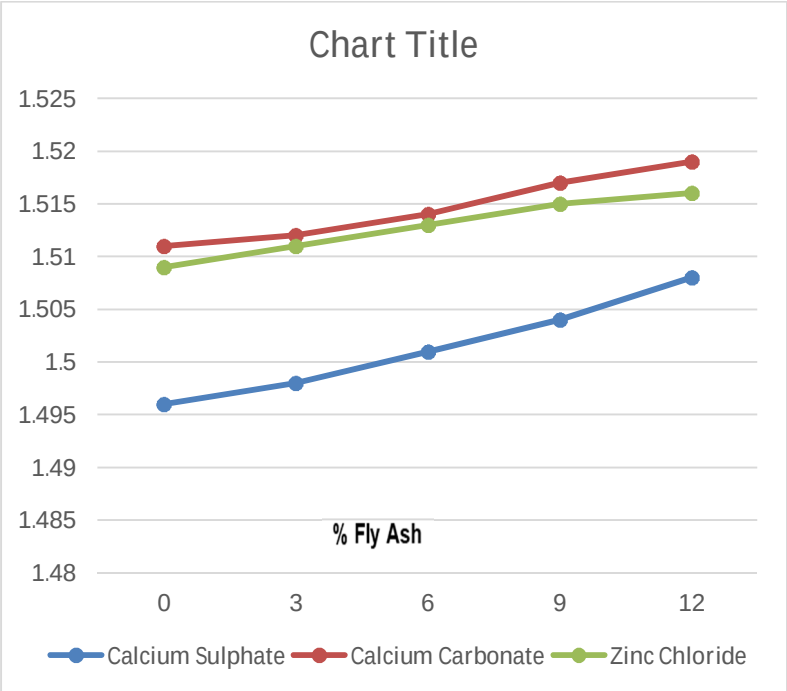
Table 5.3: Effect of 2% Zinc Chloride & Fly Ash on Maximum Dry Density

% of Soil	% of $Zncl_2$	% of Fly Ash	MDD g/cm^3
98	2%	0	1.509
95	2%	3	1.511
92	2%	6	1.513
89	2%	9	1.515
86	2%	12	1.516



Graph 4.63: Variation of MDD for 2% of Zinc Chloride & Fly Ash

From the graph 5.3, it is seen that, for 2% Zinc Chloride, the maximum dry density increases as the percentage of fly ash increases. For 12% Fly Ash, the maximum dry density increases by4.52 % Compared with raw Black Cotton il.



Graph 5.4: Comparison of Maximum Dry Density for 2% of chemicals

From the above graph, it is seen that, for 2% chemical, maximum increase in maximum dry density is observed for Zinc Chloride.

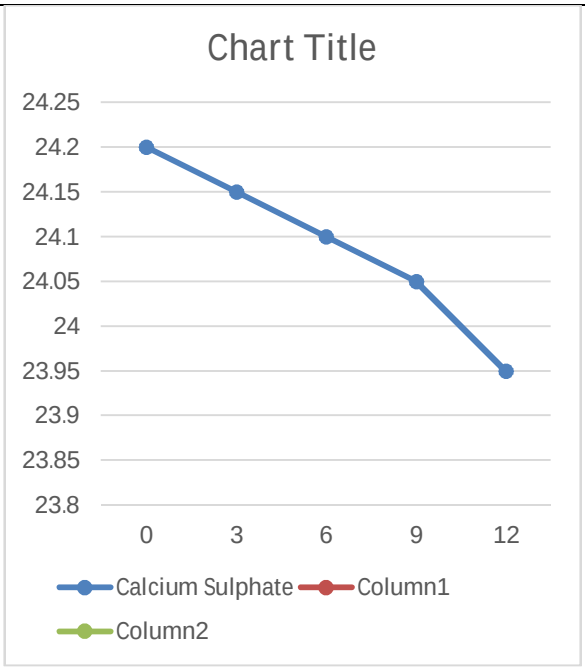
From the graph 5.3, it is observed that as percentage of chemical increases the maximum dry density increases. The maximum change in Maximum Dry Density occurs for Zinc Chloride from the graph 1.509 to 1.516 observed that the maximum dry density increases as percentage of fly ash increases. Maximum dry density is increases from for 2% Zinc Chloride and 12% Fly Ash.

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C. Observations & Graphical Representation of Optimum Moisture Content

Table 6.1: Effect of 2% Calcium Sulphate & Fly Ash on Optimum Moisture Content

% of Soil	% of $Caso_4$	% of Fly Ash	OMC
98	2.0%	0	24.20
95	2.0%	3	24.15
92	2.0%	6	24.10
89	2.0%	9	24.05
86	2.0%	12	23.95

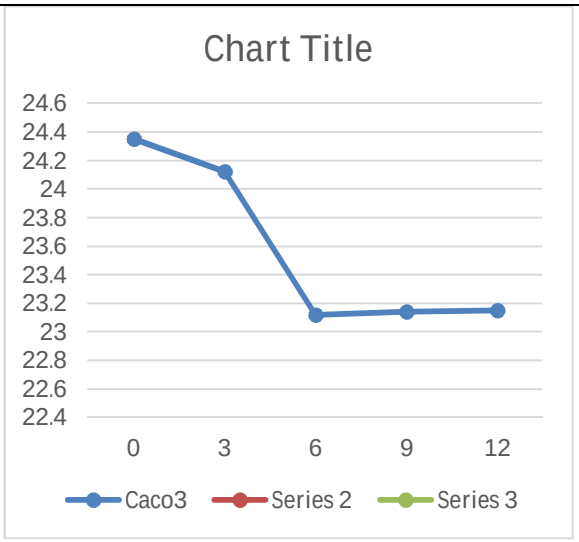


Graph 6.1: Variation of OMC for 2% Calcium Sulphate & Fly Ash

From the graph 6.1, it is seen that, for 2% Calcium Sulphate, Optimum Moisture Content decreases as the percentage of fly ash increases. For 12% fly ash the OMC reduces by 5.71%.

Table 6.2: Effect of 2% Calcium Carbonate & Fly Ash on OMC

% of Soil	% of $Caco_3$	% of Fly Ash	OMC
98	2%	0	24.35
95	2%	3	24.12
92	2%	6	23.12
89	2%	9	23.14
86	2%	12	23.15



Graph 6.2: Variation of OMC for 2% Calcium Carbonate & Fly Ash

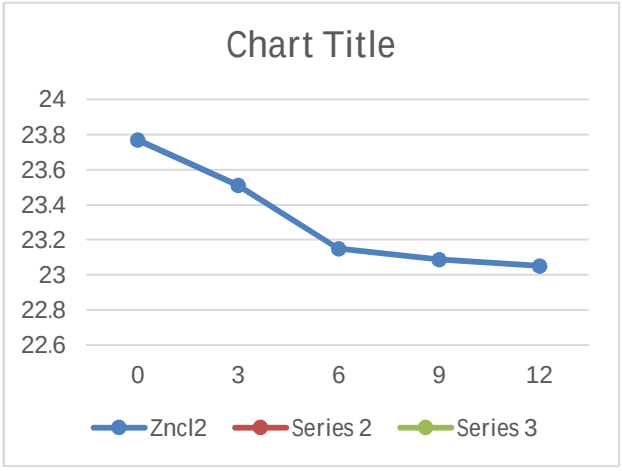
From the above graph, it is seen that, for 2% Calcium Carbonate, as the percentage of fly ash increases, the optimum moisture content decreases. For 12% fly ash, OMC reduces by 4.69 % Compared with raw Black Cotton Soil

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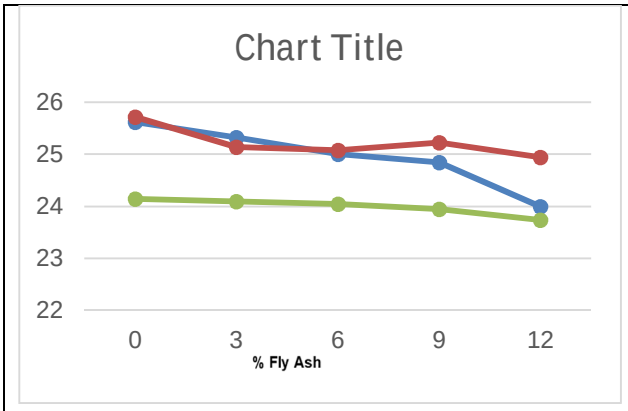
Table 6.3: Effect of 2% Zinc Chloride & Fly Ash on OMC

% of Soil	% of $Zncl_2$	% of Fly Ash	OMC
98	2%	0	23.77
95	2%	3	23.51
92	2%	6	23.15
89	2%	9	23.09
86	2%	12	23.05

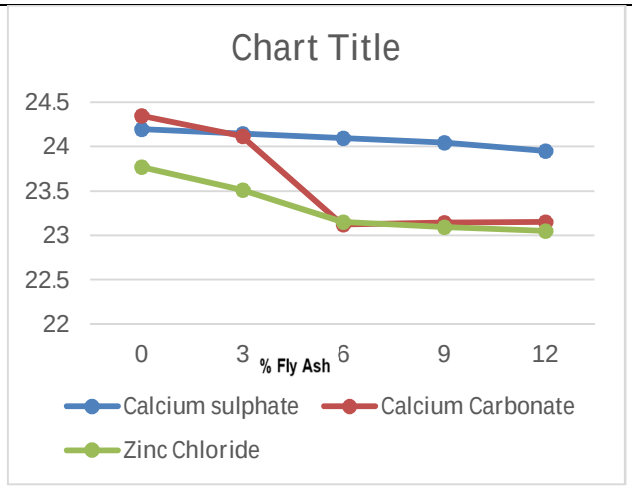
Graph 6.3: Variation of OMC for 2% Zinc Chloride & Fly Ash



From the above graph, it is seen that, for 2% Zinc Chloride, as the percentage of fly ash increases, optimum moisture content decreases. For 12% fly ash, OMC reduces by 9.25 %Compared with raw Black Cotton Soil.



Graph 6.4: Comparison of OMC for Various Percentage of Chemical without Fly Ash



Graph 6.5: Comparison of Optimum Moisture Content for 2% of Chemicals

It is observed that maximum dry density increases and optimum moisture content decreases, as the percentage of chemical & fly ash increases.

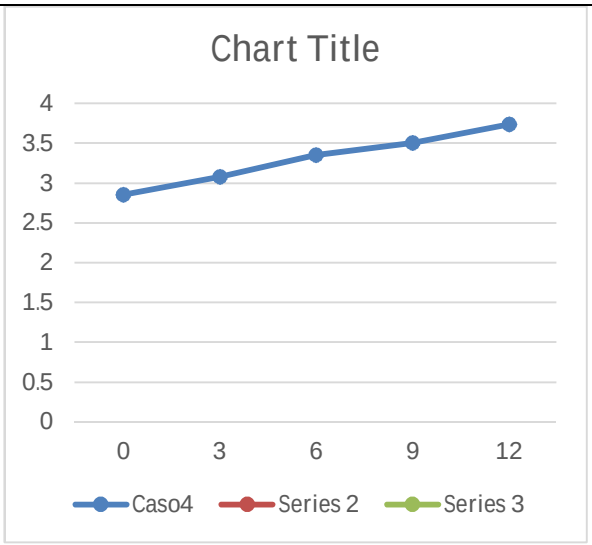
From the graph 6.5, it is observed that as percentage of chemical increases the maximum dry density increases. The maximum change in Maximum Dry Density occurs for Zinc Chloride from the graph 6.1 to 6.3, it is observed that the maximum dry density increases as percentage of fly ash increases.

The Optimum Moisture Content decreases as the percentage of Chemical and Fly Ash increases which can be seen from graph 6.1 to 6.3. Decrease in Optimum moisture Content indicates compactness betweencation soil minerals & fly ash particles.

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Table 7.1: Effect of 2% Calcium Sulphate & Fly Ash on California Bearing Ratio

% of Soil	% of $Caso_4$	% of Fly Ash	CBR
98	2.0%	0	2.85
95	2.0%	3	3.08
92	2.0%	6	3.35
89	2.0%	9	3.50
86	2.0%	12	3.74

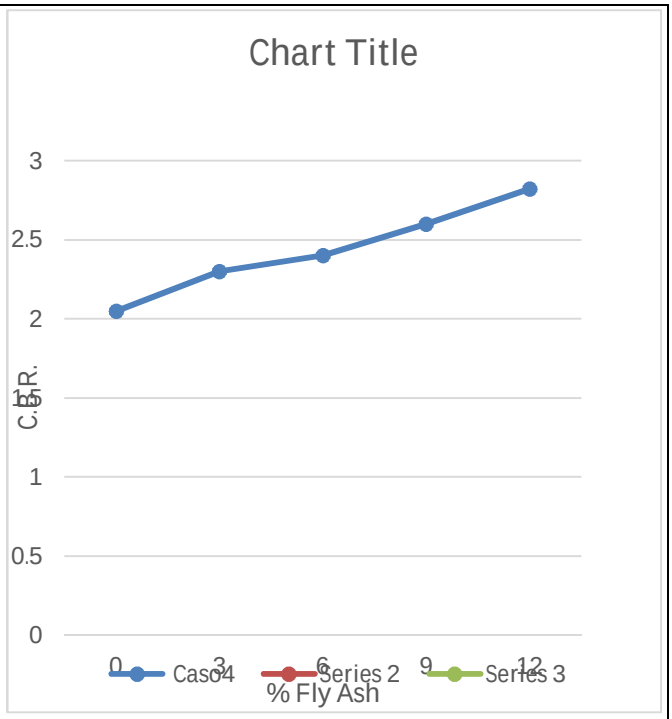


Graph 7.1: Variation of CBR for 2% Calcium Sulphate & Fly Ash

From the above graph, it is seen that, for 2% Calcium Sulphate as the percentage of fly ash increases, California Bearing Ratio increases. For 12% fly ash, CBR increases by 96.84 %.

Table 7.2: Effect of 2% Calcium Carbonate & Fly ash on California Bearing Ratio

% of Soil	% of $Caco_3$	% of Fly Ash	CBR
98	2.0%	0	3.22
95	2.0%	3	3.46
92	2.0%	6	3.70
89	2.0%	9	3.94
86	2.0%	12	4.26



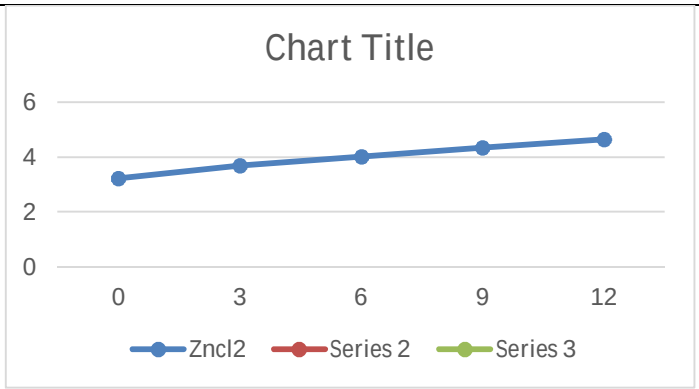
Graph 7.2: Variation of CBR for 2% Calcium Carbonate & Fly Ash

From the above graph, it is seen that, for 2% Calcium Carbonate, as the percentage of fly ash increases, California Bearing Ratio increases. For 12% fly ash, CBR increases by 124.41% Than Raw B.C.Soil.

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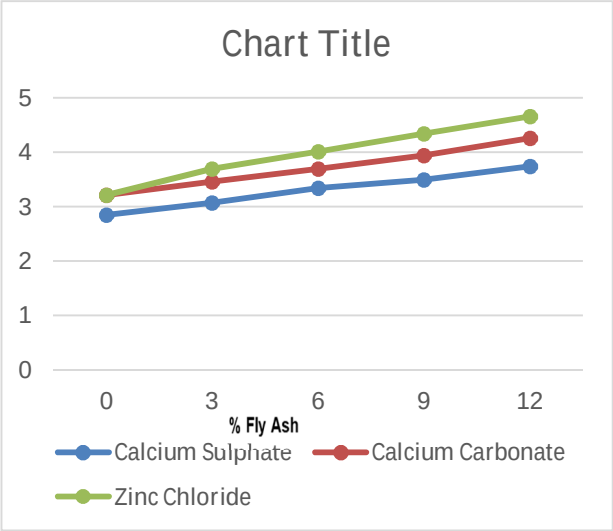
Table 7.3: Effect of 2% Zinc Chloride & Fly Ash on California Bearing Ratio

% of Soil	% of $Zncl_2$	% of Fly Ash	CBR
98	2.0%	0	3.22
95	2.0%	3	3.70
92	2.0%	6	4.02
89	2.0%	9	4.34
86	2.0%	12	4.66



Graph 7.3: Variation of CBR for 2% Zinc Chloride & Fly Ash

From the above graph, it is seen that, for 2% Zinc Chloride, as the percentage of fly ash increases, California Bearing Ratio increases. For 12% fly ash, CBR increases by 145.26 %.Than Raw B.C.Soil.



Graph 7.4: Comparison of California Bearing Ratio for 2% of Chemicals

III. CONCLUSION

A. Conclusions

1) Combination of black cotton soil:Ash: Zinc chloride Proportion 86:12:2 Decrease Liquid Limit Chemical Treatment couldbe attriributed to the depressed double layert thickness of Payvement due to cationexchange by calciumandZinc Ions.

2) It is observed that plastic Limit for zinc chloride, calcium sulphate and calcium carbonate variation in plastic limit Ngligible .But Plastic Limi to fall chemicalincrease with percentage for FlyAsh.

3) Plasticity Index in Proportion of soil : Ash : Zinc chloride (86:12:2)Reduces by 42.91% as compaired to Raw Black Cotton soil.It shows that trend in constitancy Limit indicates alteration of soil from Clayey and Silty.

4) Max.DryDensity(MDD) OF Zinc Chloride In B.C.SOIL Increases with increase in percentage of Fly Ash. It is attributed to cation exchange of zinc chloride between Layer and Formation of cementious compound Between Fly Ash and chemical.

5) Optimum Moisture Content (OMC) decreases as the percentage of Chemical and Fly Ash increases. Decrease in OMC Indicates compactness between Cation soil Minerals & Fly Ash particals.

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6) It is observed that California Bearing Ratio (CBR) is increaseing with increasing percentage of chemical & Fly Ash.Significant increase inCBR is Recordrd with addition of chemical up to 1.5% beyond this addition percentage the increase in CBR Ratio is Marginal.The increse in CBR values Of B.C.soil with addition of 2% chemical and 12% Fly Ash Mix Proportion Soil : Chemical :Fly Ash (86:2:12) Calcium Sulphate,Calcium Carbonate : Zinc Sulphate 96.24% ,124.41%, 145.26 % Respectively compaired with raw Black Cotton Soil .The increase in strength with additionof chemicals may be attributed to the cation action .Due to Cation action formation of silicate gel.Zinc chloride and fly ash CBR value shows the increase in stability of soil and resistance to penetration which helps to decrease pavement thickness.The increase in CBR Ratio is expected formation of cemetious compounds between fly ash and chemicals.

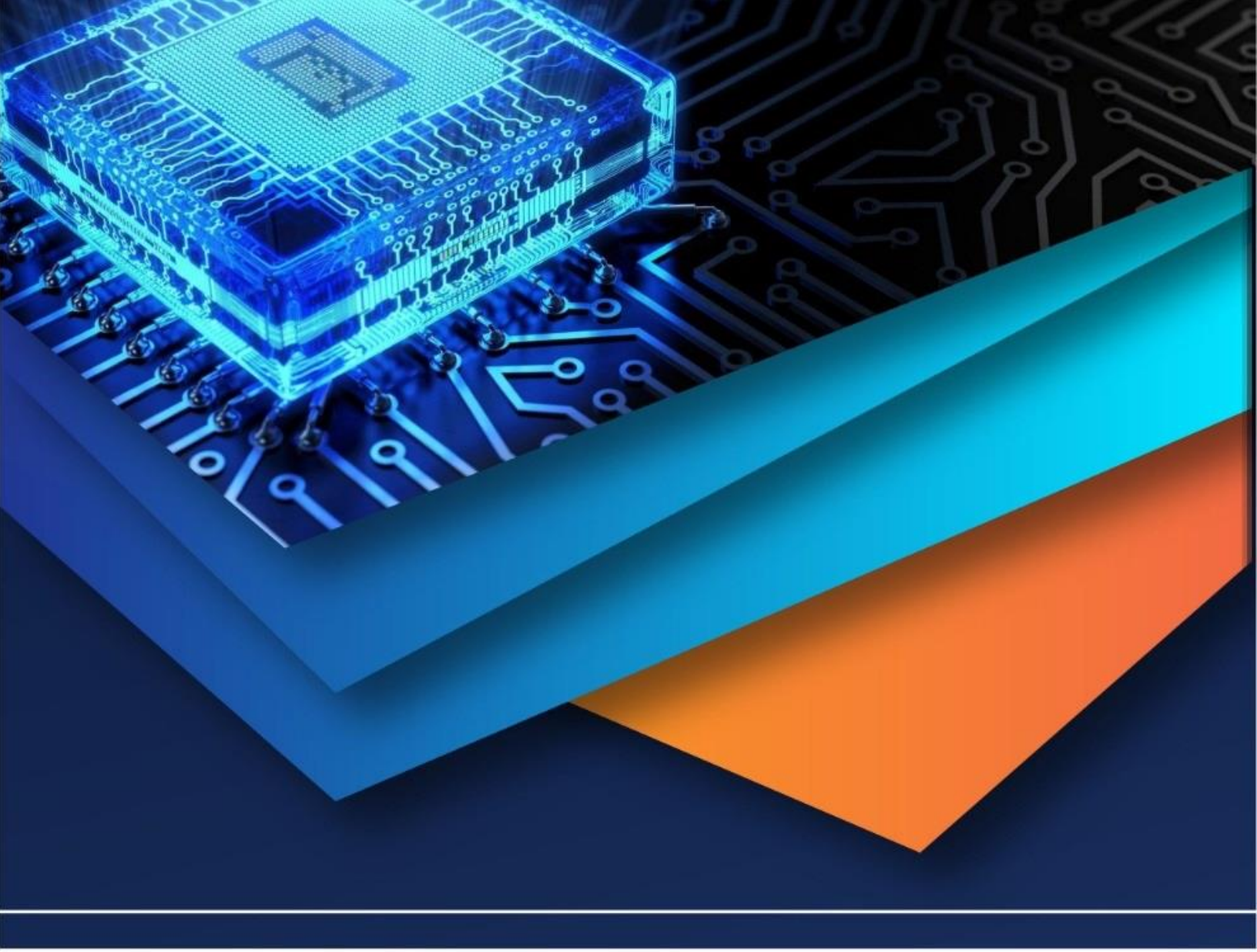
B. Economy in Use of fly ash And Chemical

Utilization of fly ash and Chemical in road work results in cutting the cost of construction by 10 to 20%. Typically, the cost of borrowed soil varies from about Rs.100 to 200 per meter. Fly ash is available free of cost at the power plant and hence only transportation cost, laying and rolling cost are there in case of fly ash. Hence, when fly ash is used as a fill material, the economy achieved is directly related to transportation cost of fly ash. If the lead distance is less, considerable savings in construction cost can be achieved. Combination of Chemical And Fly Ash Improves EngineeringProperties of soil.Instead of changingcostruction site.

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