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STABILIZATION OF BLACK COTTON SOIL USING CALCIUM CARBONATE

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Abstract: In India most of the place is covered with BC soil which causes damage to the structures. Stabilization is the process to improve the Properties of the black cotton soil. Chemical stabilization is more expensive than other type of stabilization. But the main convenient to use the chemical method is that to control the setting time and curing time. The performance of Calcium carbonate stabilized soil was evaluated using physical and strength performance test namely Atterberg's limit, Specific gravity test, Free swell index, Compaction test, CBR and UCS etc, with varying percentage of Calcium carbonate i.e.0.25%, 0.5%, 0.75% and 1% respectively.

From the experimental results, it has been observed that various properties of soil added with this stabilizer at certain percentage show remarkable positive changes as compared to the natural soil obtained. The main objective of this study is to increase the stability of the soil and reduces the construction of cost by using locally available materials. The effectiveness of $CaCo_3$ is stabilizing the black cotton soil is available in this work.

Keywords: Black cotton soil, Calcium carbonate, MDD, CBR, UCS.

I. INTRODUCTION

In India, nearly 51.8 million hectares of land is covered with expansive black cotton soil. There are many kinds of soils which shows change in volume due to change in moisture content. This causes changes on properties of soil. This also damage the property constructed on it. For developing the countries major obligatory is to provide proper road system by predictable method. Good quality of subgrade soil is desirable for road construction but it's not always obtainable for highway construction. A road pavement faces major problematic in the natural soil which is weak or unsuitable subgrade. In this situation behavior of soil properties will be enhanced by using appropriate admixture know as stabilization of soil.

In field construction many activities have to be come across with this expensive soil, in field it can be used as construction material for transferring the loads through foundation elements. This requires proper remedial measure to change the soil with respect to control the swelling behavior of Black cotton soil and to increase the strength.

Stabilization of soil is the process by which soil is treating in such a manner that it has to increase their physical properties. Shear strength of black cotton soil is increased by soil stabilization process which also control the shrinkage, swell properties of the BC soil, thus it improve the load bearing capacity of a subgrade to support the pavement and also the foundation

II. LITERATURE REVIEW

"Efficacy of Sodium Carbonate and Calcium Carbonate in stabilizing a black cotton soil", by P. Ramesh and A. V. Narasimha Rao, et.al. (Vol 2, October 2012) [5], in their study observed that the efficacy of $CaCo_3$ is much better than from strength Na_2CO_3 and stability. 2% of the chemical is effective in reducing the swelling characteristics in the tested range. $CaCo_3$ is more effective than Na_2CO_3 for reducing the OMC and in increasing the MDD. The maximum improvement in CBR values was observed to be 38.46% and 130.6%, when the soil is mixed with Na_2CO_3 and $CaCO_3$ respectively. In both types of chemicals, the maximum improvement occurs at 1.0% of the chemical. It was observed that maximum improvement in CBR value occurs 1% of $CaCo_3$.

The maximum improvement in UCS occurs at 0.75% when the soil is admixed with either Na_2CO_3 or $CaCO_3$. It was observed that $CaCo_3$ is more effective than sodium carbonate to improve the UCS value.

Hence the efficacy of $CaCO_3$ is much better than Na_2CO_3.

III.OBJECTIVES OF THE STUDY

Main objective of the present study is to determine the performance of the soil on addition of calcium carbonate stabilizer through extensive laboratory studies.

1. Determination of Index properties of the soil and specific gravity test.
2. Determination of OMC and MDD of black cotton soil stabilized with 025%, 0.5%, 0.75% and 1% of calcium carbonate.

3. Determining the optimum percentage of calcium carbonate required to obtain maximum strength or CBR of the soil.
4. To understand the effect of CaCo3 on UCS of the soil.

IV.EXPERIMENTAL INVESTIGATIONS

BLACK COTTON SOIL

The BC soil is collected from Hiriyur in Chitradurga district of Karnataka for this study at a depth of 2 m from the natural ground level. The obtained soil was air dried and pulverized manually. All the tests were conducted as per IS-2720 Standards.

Table 4.1: Physical properties of WFS

Sl.no	Property	Values
1	Specific Gravity	2.42
2	Swell Index (%)	125
3	Liquid Limit (%)	72
4	Plastic Limit (%)	30
5	Plastic Index (%)	42
6	OMC(%)	22
7	MDD(%)	1.728
8	Soaked CBR (%)	2.12
9	UCS KN/m^2	113.27
10	IS classification	MH-OH

CALCIUM CARBONATE

Calcium carbonate is a compound of calcium and carbon dioxide. It is a common substance found as rock in all parts of the world. It is the main component of shells of marine organisms, snails, and egg shells.
Chemical solution is prepared by dissolving chemical powder in distilled water. The percentages of chemical are varied from 0.25, 0.50, 0.75 and1.0 by weight of the soil.

Table 4.2: Physical properties of $CaCo_3$

Color	white
PH	9.1
Density	2.71 g/cm^3
Melting point	825^oC

V. TESTS CONDUCTED

The following tests are conducted in this investigation:
1. Grain size distribution
2. Liquid limit tests
3. Plastic limit tests
4. Free Swell Index Tests
5. Specific gravity test.
6. Compaction tests
7. California Bearing Ratio tests
8. Unconfined compression strength tests

VI.RESULTS

6.1. Specific Gravity Test

Table.6.1.Specific gravity for various percentage of $CaCo_3$

Description	Soil sample + 0% of $CaCo_3$	Soil sample + 0.25% of $CaCo_3$	Soil sample + 0.5% of $CaCo_3$	Soil sample + 0.75% of $CaCo_3$	Soil sample + 1% of $CaCo_3$
Specific gravity	2.42	2.45	2.75	2.50	2.46

6.2. Free Sweel Index

Table.6.2. FSI for various percentage of $CaCo_3$

Description	Soil sample	Soil sample + 0.25% of $CaCo_3$	Soil sample + 0.5% of $CaCo_3$	Soil sample + 0.75% of $CaCo_3$	Soil sample + 1% of $CaCo_3$
FSI %	125	52.85	49.45	46.56	33.25

6.3. Liquid Limit and Plastic Limit Test

Table.6.3. Liquid and Plastic limit for various percentage of $CaCo_3$

Description	Soil sample +0% $CaCo_3$	Soil sample + 0.25% of $CaCo_3$	Soil sample + 0.5% of $CaCo_3$	Soil sample + 0.75% of $CaCo_3$	Soil sample + 1% of $CaCo_3$
LL %	72	62	52	58	55
PL %	30	29	25	28	27
PI %	42	33	27	30	28

6.4. Standard Proctor Compaction test

Table.6.4.Various MDD and OMC for different percentage of $CaCo_3$

Material	MDD gm/cc	OMC %
Soil sample + 0% of $CaCo_3$	1.728	22
Soil sample + 0.25% of $CaCo_3$	1.88	22.17
Soil sample + 0.5% of $CaCo_3$	2.14	22.21
Soil sample + 0.75% of $CaCo_3$	1.97	22.17
Soil sample + 1% of $CaCo_3$	1.69	22.20

6.5. Soaked CBR Test

Table.6.5.CBR results for varying percentage of $CaCo_3$

Description	CBR value for 2.5 mm penetration	CBR value for 5 mm penetration
Soil sample + 0% of $CaCo_3$	2.12%	1.94%
Soil sample + 0.25% of $CaCo_3$	8.21%	6.88%
Soil sample + 0.5% of CaCo3	14.5%	12%
Soil sample + 0.75% of CaCo3	12.18%	11%
Soil sample + 1% of CaCo3	9.28%	8%

6.6. Unconfined Compression Test

Table.6.6.UCS results for varying percentage of $CaCo_3$

Material	UCS KN/m^2 (7 days)	UCS KN/m^2 (14 days)
Soil sample + 0% of $CaCo_3$	84.95	113.27
Soil sample + 0.25% of $CaCo_3$	198.23	254.86
Soil sample + 0.5% of $CaCo_3$	264.30	320.94
Soil sample + 0.75% of $CaCo_3$	226.54	264.30
Soil sample + 1% of $CaCo_3$	207.67	217.11

VII.DISCUSSION

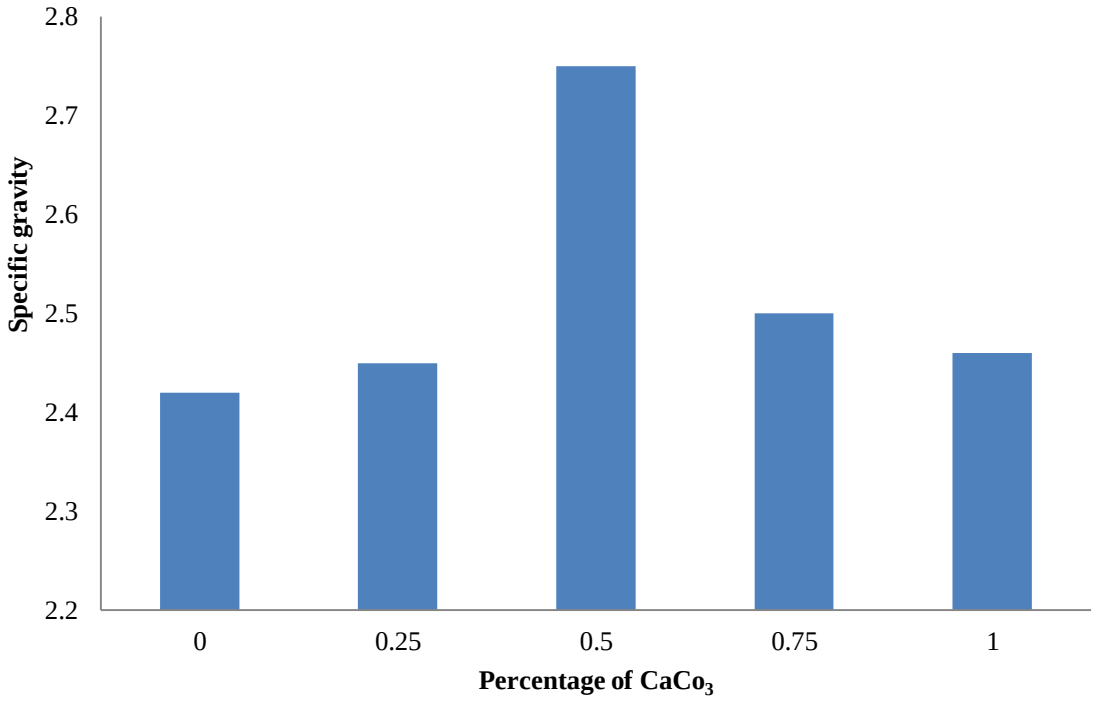

Figure.7.1. Variation of Specific gravity with varying parentage of $CaCo_3$

Addition of calcium carbonate at 0.25%, 0.5%, 0.75% and 1% the specific gravity of soil goes on increases i.e. 2.42 to 2.45, 2.75, 2.50 and 2.46 respectively observed from the above bar chart. From these values maximum specific gravity value can be obtained at 0.5% of calcium carbonate treated soil increases from 2.42 to 2.75. Further increasing the percentage of calcium carbonate it has been observed that specific gravity values will be decreases. Hence 0.5% of calcium carbonate has been considered as optimum.

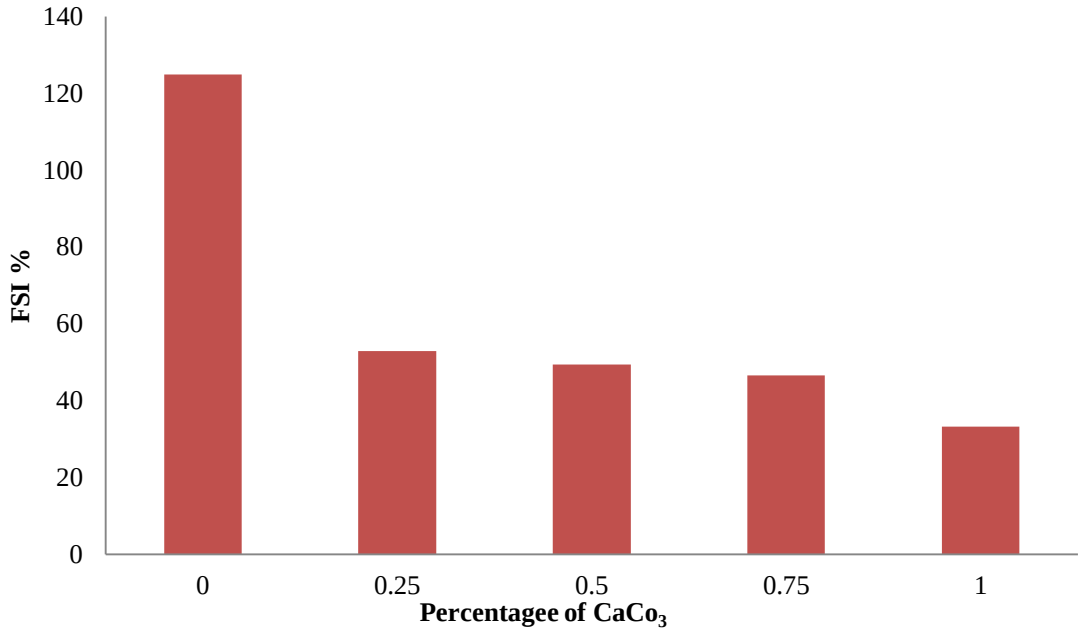

Figure.7.2.Variation of FSI with varying parentage of $CaCo_3$

From the above bar chart it is observed that addition of varying percentage of calcium carbonate i.e. 0.25%, 0.5%, 0.75% and 1% swelling index goes on decreases i.e.52.85%, 49.45%, 46.56%, and 33.25% respectively. Further increasing the percentage of calcium carbonate it has been observed that swelling values decreases.

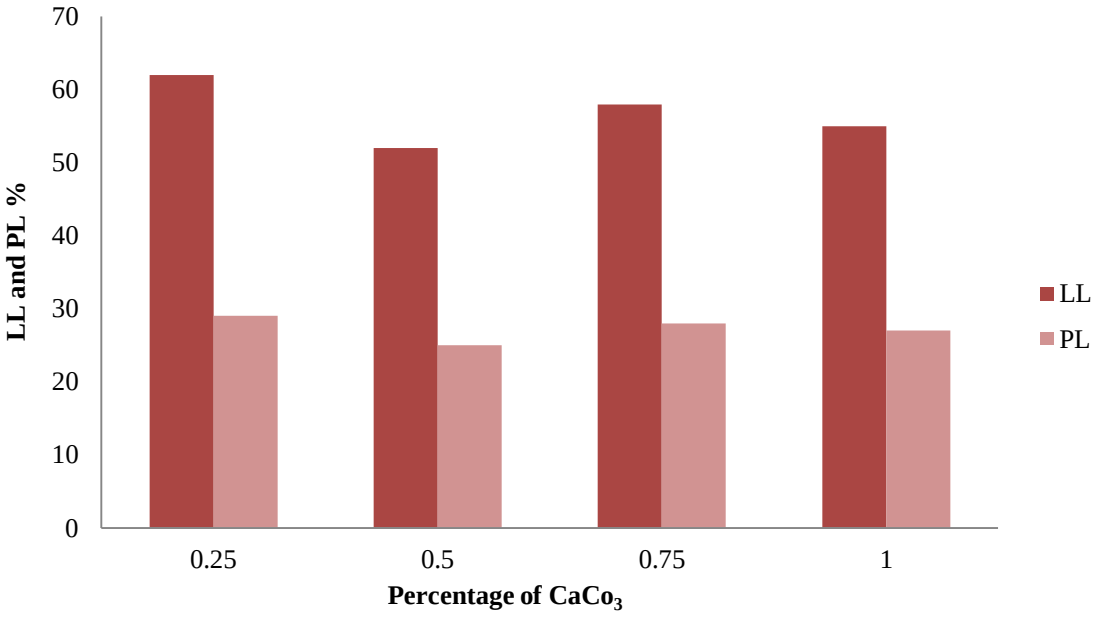

Figure.7.3. Variation of LL and PL with varying parentage of $CaCo_3$

The liquid limit of the calcium carbonate treated soil sample is decreased compared to the untreated soil sample. From the above results it is observed that at 0.5% calcium carbonate the liquid limit is minimum and hence it can be concluded it as the optimum dosage.

The plastic limit of the untreated soil is 30%, when the soil treated with stabilizer the plastic limit is slightly decreased i.e. 25%. The maximum decreasing can be observed at 0.5% of calcium carbonate from the above bar chart.

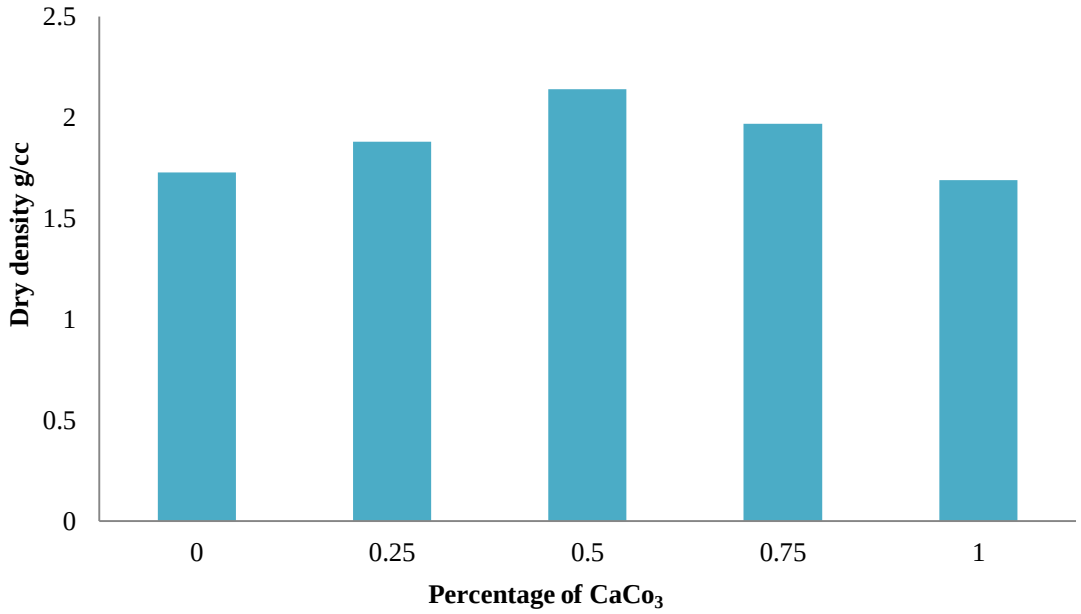

Figure.7.4. Variation of dry density with varying parentage of $CaCo_3$

From the above bar chart it has been observed that by adding varying percentage of Calcium carbonate i.e. 0.25%, 0.5%, 0.75% and 1% to the soil sample maximum dry density values increases i.e. 1.88g/cc, 2.14g/cc, 1.97g/cc and 1.69 g/cc. From these values maximum MDD obtained at 0.5% of calcium carbonate with soil sample is 2.14 g/cc. Further increasing the percentage of calcium carbonate decrease of MDD is noticed. Hence 0.5% of calcium carbonate has been considered as optimum.

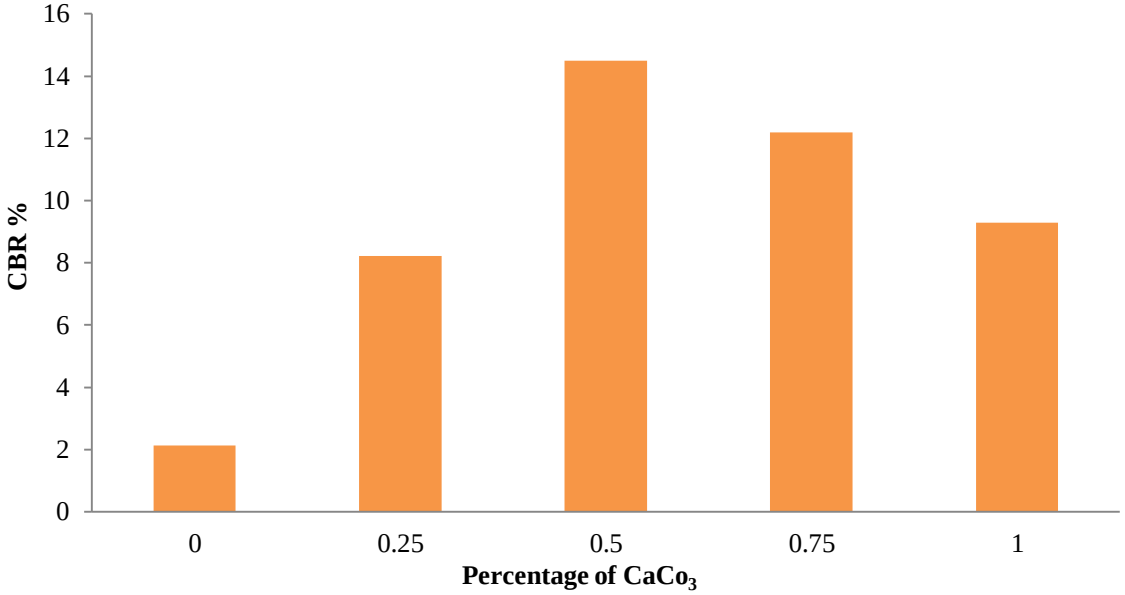

Figure.7.5. Variation of Soaked CBR values with varying parentage of $CaCo_3$

The varying percentage of calcium carbonate i.e. 0.25%, 0.5%, 0.75% and 1% mixed to the soil the obtained CBR values i.e.8.21%, 14.5%, 12.18% and 9.28%, respectively. Maximum value of CBR obtained at 0.5% of calcium carbonate i.e. increases from 2.12% to 14.5%. Hence from this observation 0.5% of calcium carbonate considered as optimum percent in this case.

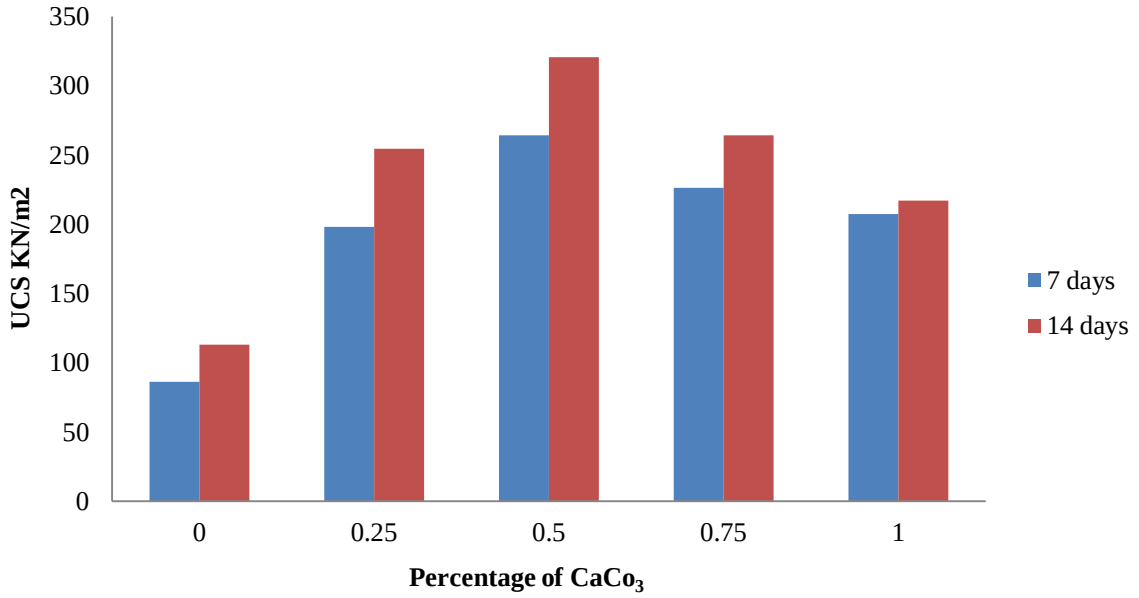

Figure.7.6.Variation of UCS with varying parentage of $CaCo_3$

Varying percentage i.e. 0.25%, 0.5%, 0.75% and 1% calcium carbonate mixed to the soil sample gives various UCS values i.e. 113.27 KN/m^2 to 254.86 KN/m^2, 320.94 KN/m^2, 264.30 KN/m^2 and 217.11 KN/m^2 observed from the above bar chart.

For 7 days of curing UCS values will be improved lightly, for 14 days curing it has been observed that more improvement in the values compares to 7 days values. Maximum value of UCS will be obtained at 0.5% of calcium carbonate by 320.94 KN/m^2. Hence from this observation 0.5% of calcium carbonate considered as optimum percent in this case.

CONCLUSION

Following are the conclusions drawn from this study.

1. At 0.5% of $CaCo_3$ the LL and PL reduces by 27.7% and 3.33% respectively.
2. The FSI decreases with increase in the percentage of $CaCo_3$.
3. At 0.5% of $CaCo_3$ the Specific gravity increases from 2.45 to 2.75 respectively.
4. The OMC and MDD for 0.25%, 0.5%, 0.75% and 1% observed to be 1.88 g/cc, 2.14 g/cc, 1.97 g/cc and 1.69 g/cc. The maximum MDD is maximum at 0.5%.
5. The maximum CBR value found to be 14.5% at a dosage of 0.5% $CaCo_3$, further increasing $CaCo_3$ results in decrease of CBR values.
6. The maximum UCS value found to be 320.94 KN/m^2 at a dosage of 0.5% $CaCo_3$.
7. With mentioning the above test outcomes it seems that addition of 0.5% of $CaCo_3$ stabilizer can consider as optimum percentage of chemical treated to the BC soil.

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