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Research Paper

EFFECT OF CRUSHER DUST ON ENGINEERING PROPERTIES OF LIME STABILIZED BLACK COTTON SOIL

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The effect of crusher dust on the engineering characteristics of Black Cotton soil is presented in this paper. The soil Sample used is stabilized with 5% lime. A laboratory study was undertaken to evaluate the effect of crusher dust as a soil stabilizer. Soil sample containing 5% lime and 10% and 20% of crusher dust were prepared and compaction characteristic and California bearing ratio test were conducted as per relevant IS code of practise. The test results revealed that the compaction parameters and CBR values of the soil are improved substantially with the addition of the granite dust. The result showed the CBR value increased from 1.7% to 7.15%, the optimum moisture content have been reduced from 22% to 14.3% and the maximum dry density have been increased from 1.58 g/cc to 1.88 g/cc. The conclusion drawn from this experimental work is that the expansive clay like black cotton soil can be stabilized by the combination of lime and crusher dust to increase the stability.

Keywords: Black cotton soil, Crusher dust, California bearing ratio, Compaction characteristics

INTRODUCTION

Black cotton soil is found mostly in the central and western parts and covers approximately 20% of the total area of India. Most of black-cotton soils of India are spread across the Deccan Lava Plateau, the Malwa Plateau, and interior Gujarat, where there is both moderate rainfall and underlying basaltic rock. Because of their high clay content, black soils develop wide cracks during the dry season, but their iron-rich granular structure makes them resistant to wind and water erosion. The black cotton soils in India have liquid limit values ranging from 50 to 100%, plasticity index ranging from 20 to 65% and shrinkage limit from 9 to 14%. The minus 2 micron fraction in the soil varies from 40 to 75%. The maximum dry density varies from 14 to 17 kN/m^3 and the optimum moisture content varies from 18 to 30%. The color of such soils is dark grey to black.

The swelling potential of a soil is directly related to the plasticity index of the soil. A low shrinkage limit indicated that a soil would begin

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to swell at low water content. The colloidal content (–1 micron fraction) constituted the most active part of the soil contributing to swelling.

MATERIALS AND METHODS

Black cotton soil: The soil sample is collected from Vijay Nagar, Jabalpur. The black cotton soil collected from the site was brought to the laboratory for testing. Before testing it was assured that the soil is free from any organic matter, polythene, etc. The soil collected was made oven dried for testing purpose. **The normal range of chemical properties of black cotton soil are shown in Table 1.**

Crusher dust: The crusher dust was brought from the stone crushers established at the outskirts of Jabalpur near Pipariya .

Lime: The commercially available lime was brought from market and made free from lumps. It was kept in air tight polythene bags.

Sample preparation: The samples used in the study are prepared by blending black cotton soil with different percentage of crusher dust, using lime as stabilizer. Oven dried ingredients (CD, BC, Lime) were taken for the sample preparation for accurate proportioning by weight. The water is used to blend the mix properly. The samples are prepared as such:

- The black cotton soil, lime, crusher dust are oven dried separately.
- The oven dried black cotton soil; lime (5%) and crusher dust in different proportion (10%, 20% respectively) are mixed together in proportions by weight to form various mixes.
- The formed dry mixes are being blended together with water in order to get a homogenous blend.
- The formed blends are kept aside for 24 h and then oven dried.

These oven dried blends are now ready for laboratory testing and treated as samples. 5 Tests performed on different mixes

In the present the following tests were conducted on all samples as per the relevant IS code of practice:

- Grain size distribution.
- Liquid Limit

Table 1: Normal Range of Chemical Properties of Black Cotton Soil

S. No.	Description	Formula	Range
1.	Silica	SiO_2	48-58(%)
2.	Alumina	Al_2O_3	13-22(%)
3.	Lime	CaO	1-8(%)
4.	Magnesium Oxide	MgO	1.8-5.0(%)
5.	Ferric Oxide	Fe_2O_3	7.5-1.5(%)
6.	Sulphate	SO_4	0.9-2.0(%)
7.	Carbonates	CO_3	0.5-6.6(%)
8.	Organic Matter	-	0.4-3.6(%)
9.	pH	-	6.7-8.9

- Plastic Limit.
- Shrinkage Limit.
- Proctor Test.

The details of different soil mixes prepared for the experimental work are as under.

L0S0-Black cotton soil without any stabilizer and without crusher dust

L5S0-Black cotton soil with stabilizer (5% Lime) and without crusher dust

L5S10-Black cotton soil with Stabilizer (5% Lime) and crusher Dust 10%

L5S20-Black cotton soil with Stabilizer (5% Lime) and crusher Dust 20%

Grain Size Distribution (IS: 460-1962)

For soil samples of soil retained on 75 micron I.S sieve. The proportion of soil sample retained on 75 micron I.S sieve is weighed and recorded weight of soil sample is as per I.S 2720. I.S sieves are selected and arranged in the order as shown in the table. The soil sample is separated into various fractions by sieving through above sieves placed in the above mentioned order. The weight of soil retained on each sieve is recorded. The moisture content of soil, if above 5% it is to be measured and recorded. No particle of soil sample shall be pushed through the sieves.

Particle Size Distribution: Dry sieve analysis on crusher dust has been conducted and the results are shown in Table 2.

Liquid Limit (IS: 2720 (Part 5) - 1985.)

The casagrande apparatus is used to determine the liquid limit of the soil. The Liquid Limit (LL) is the water content at which a soil changes from plastic to liquid behavior. Soil is placed into the metal cup of the device and a groove is made down its centre with a standardized tool of 13.5 mm width. The cup is repeatedly dropped 10 mm onto a hard rubber base at a rate of 120 blows per minute, during which the groove closes up gradually as a result of the impact. The number of blows for the groove to close is recorded. The

Table 2: Sieve Analysis of Crusher Dust

Total weight= 1000g

S.No.	IS Sieve	Mass Retained (gm)	% Mass Retained	Cumulative % Mass Retained	% Finer
1	4.75mm	14	1.4	1.4	98.6
2	2.0 mm	8	0.8	2.2	97.8
3	1.00 mm	8	0.8	3.0	97.0
4	600µ	44	4.4	7.4	92.6
5	425 µ	233	23.3	30.7	69.3
6	300 µ	54	5.4	36.1	63.9
7	212 µ	268	26.8	62.9	37.1
8	150 µ	154	15.4	78.3	21.7
9	75µ	170	17.0	95.3	4.7
10	Pan	47	4.7	100	0

moisture content at which it takes 25 drops of the cup to cause the groove to close over a distance of 13.5 mm is defined as the liquid limit. The test is normally run at several moisture contents, and the moisture content which requires 25 blows to close the groove is interpolated from the test results. Variation in the value of liquid limit is shown in Chart 1.

Plastic Limit (IS: 2720 (Part 5) - 1985)

The plastic limit is determined by rolling out a thread of the fine portion of a soil on a flat, nonporous surface. If the soil is plastic, this thread will retain its shape down to a very narrow diameter. The sample can then be remolded and the test repeated. As the moisture content falls due to evaporation, the thread will begin to break apart at larger diameters. The plastic limit is defined as the moisture content where the thread breaks apart at a diameter of 3 mm. A soil is considered non-plastic if a thread cannot be rolled out down to 3 mm at any moisture. Variation in the value of Plastic limit is shown in Chart 2.

Shrinkage Limit (IS: 2720 Part VII 1980/87)

The Shrinkage Limit (SL) is the water content when the water is just sufficient to fill all the pores of the soil and the soil is just saturated. The volume of soil does not decrease when the water content is reduced below the Shrinkage limit. It can be determined from the following relation:

$$Ws = \{W_c-(V-V_d)/M_d\}*100$$

where, M_1= Initial wet mass

M_d = Dry mass

V = Initial volume

V_d = Volume after drying

Ws=Shrinkage limit

W_c = Water content

Variation in the shrinkage limit of the soil is shown in Chart 3.

Plasticity Index (IS2720 Part VII 1980/87)

The plasticity index (PI) is a measure of the plasticity of a soil. The plasticity index is the size

Chart 1: Variation of Liquid Limit with Various Quantities of Crusher Dust

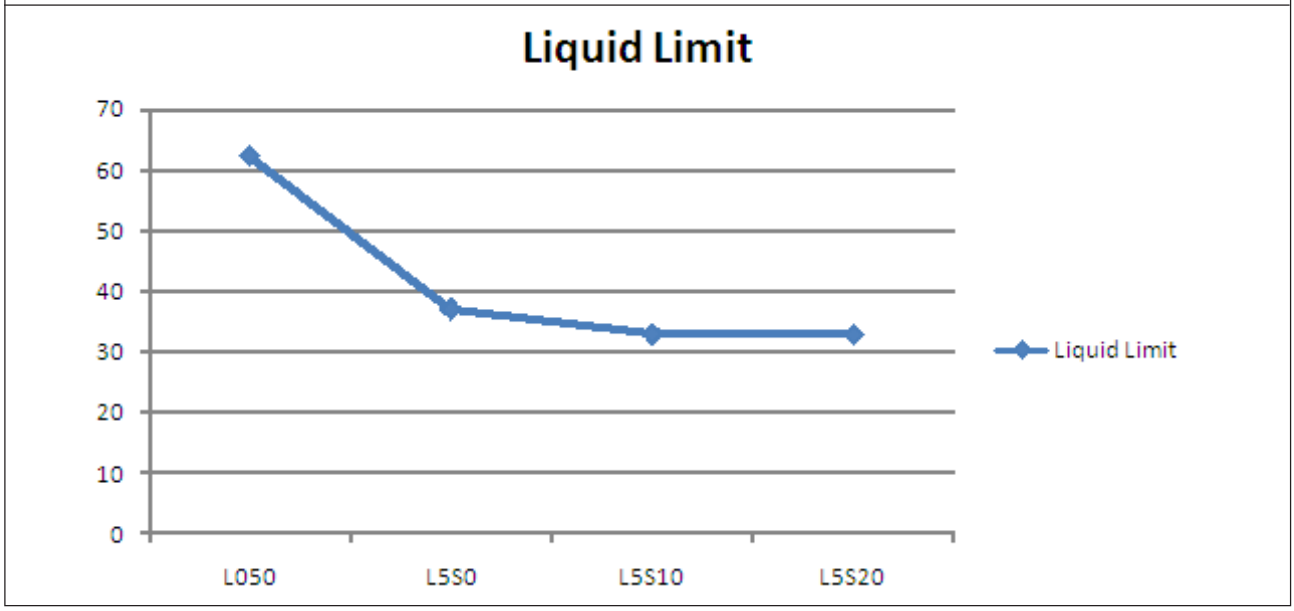


Chart 2: Variation of Plastic Limit with Various Quantities of Crusher Dust

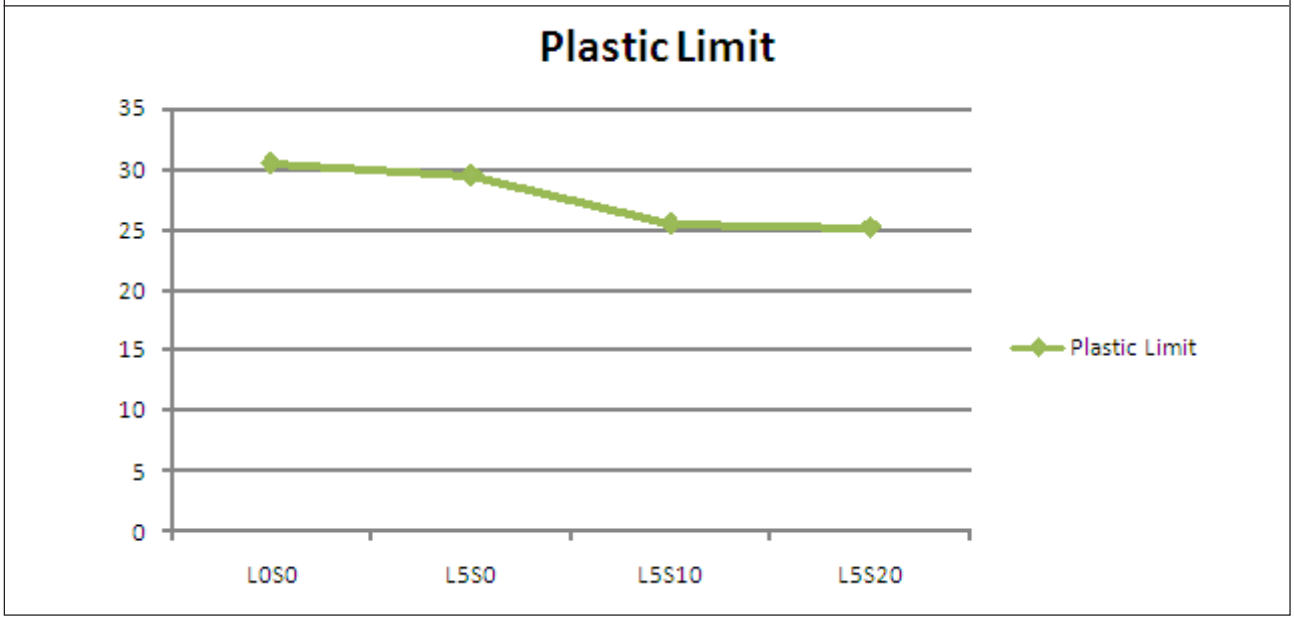
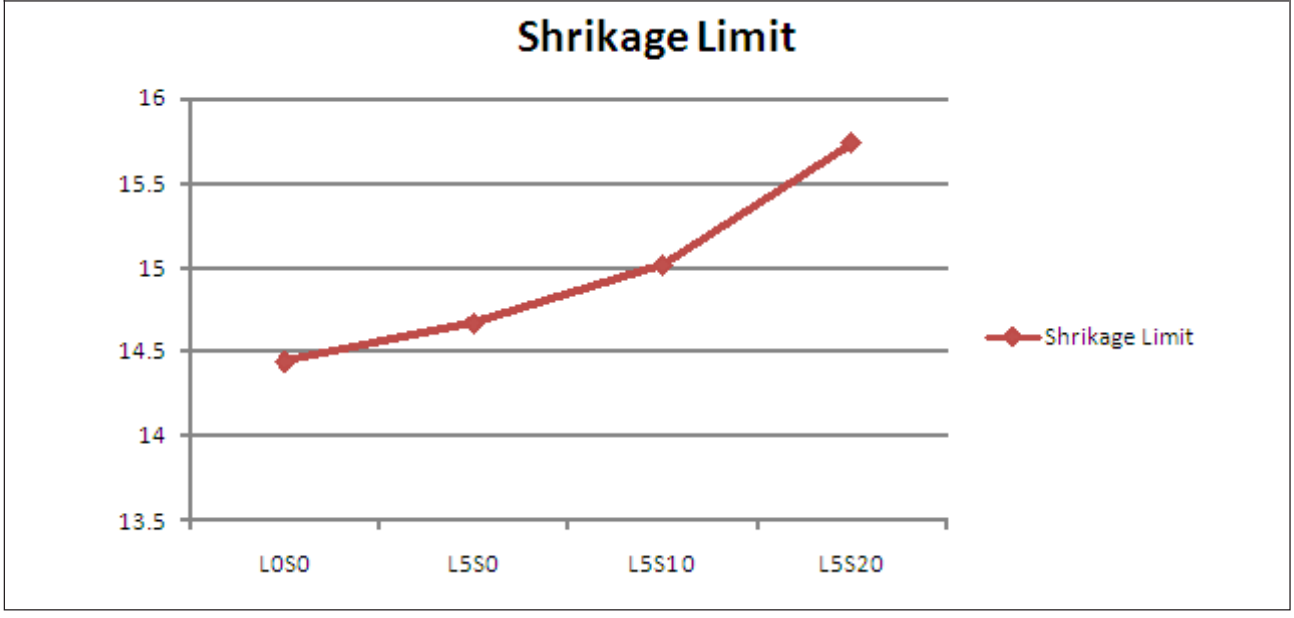


Chart 3: Variation of Shrinkage Limit with Various Quantities of Crusher Dust



of the range of water contents where the soil exhibits plastic properties. PI values and their meanings

0 – Nonplastic	(10-20)-Medium plasticity
(1-5)- Slightly plastic	(20-40) - High plasticity
(5-10) - Low plasticity	>40 Very high plasticity

Standard Proctor Test (IS2720 Part VIII 1980/87)

Compaction is the process by which the bulk density of an aggregate of matter is increased by driving out air. For any soil, for a given amount of compactive effort, the density obtained depends on the moisture content. At very high

moisture contents, the maximum dry density is achieved when the soil is compacted to nearly saturation, where (almost) all the air is driven out. At low moisture contents, the soil particles interfere with each other; addition of some moisture will allow greater bulk densities, with a peak density where this effect begins to be counteracted by the saturation of the soil.

The Standard Proctor test was developed by RR PROCTOR (1933) for construction of earth fill dams in state of California.

It is done in a cylindrical mould having an internal diameter of 4 inches (10.15 cm) an internal effective height of 4.6 inches (11.7 cm) and a capacity of 945 cc . Mould has detachable collar and base plate assembly. Mechanically operated hammer has a face diameter of 50.8 mm that is 5.08 cm and a free falling weight of 2.5 kg rammer, falling at a height of 30 cm or 0.3 m. The soil is filled in 3 layers each being given 25 blows . But the mould used in the experiment has a diameter of about 6 inches (15.24 cm) an a volume of 2240 cc hence 56 blows are provided for equal compactive effort .

ρ = M/V (g/cc) $\rho_d = \rho / (1+w)$ (g/cc)

where, ρ = Bulk density of soil (g/cc)

ρ_d = Dry density of soil (g/cc)

M = Mass of the wet compacted specimen (g)

V = Volume of the mould, 2240 cc

The value of Optimum Moisture Content (OMC) in the table is in percentage.

The value of Maximum Dry Density (MDD) is in g/cc.

RESULTS

The experimental results show that there is considerable improvement in the soil properties with addition of Crusher dust. The results obtained from various laboratory tests are summarized below.

Chart 4: Variation of OMC with Various Quantities of Crusher Dust

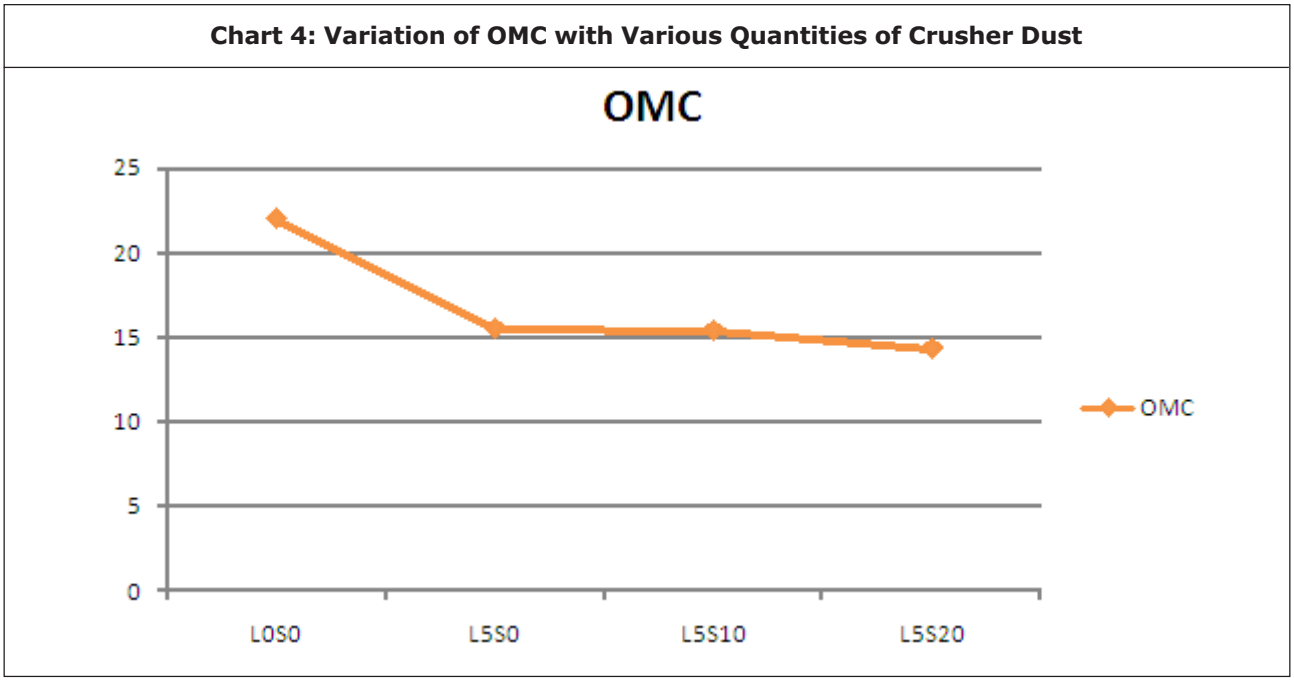
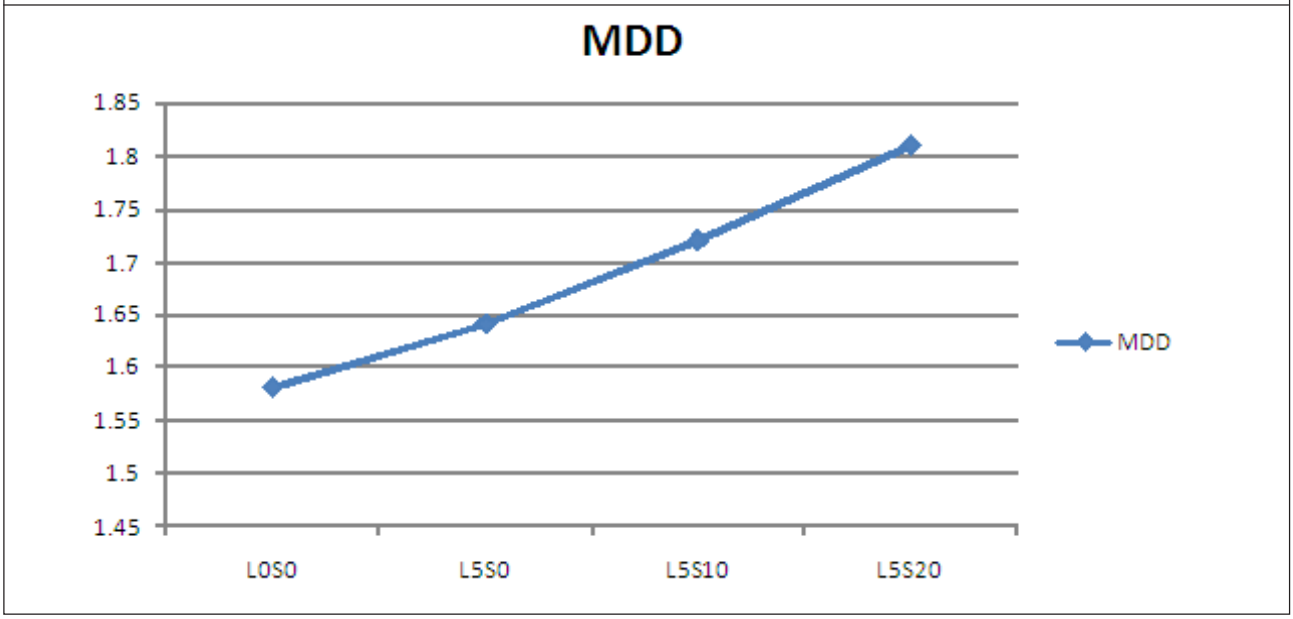


Chart 5: Variation of MDD with various quantities of Crusher Dust



S.No.	Type of Sample	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Shrinkage Limit (%)	Compaction Characteristics	
						OMC (%)	MDD (gm/cc)
1	L0S0	62.31	30.46	31.85	14.44	22	1.58
2	L5S0	37.12	29.5	7.62	14.67	15.5	1.64
3	L5S10	33.04	25.5	7.54	15.02	15.4	1.72
4	L5S20	33	26.2	6.8	15.74	14.3	1.81

CONCLUSION

Crusher dust is a waste material generated from stone industries. The experimental work was carried out to study the use of crusher dust for the improvement of swelling and shrinkage, compaction characteristics values of Lime Stabilized Black Cotton Soil.

Based on the laboratory tests conducted on black cotton soil mixed with 5% lime and 0%, 10%, 20% of crusher dust by weight of dry clay, the following conclusions can be drawn:

1. The Liquid limit values of the samples are decreasing with increase in the amount of crusher dust.
2. Shrinkage limit is increasing from 14.4% to 15.4% with the increase in the percent of crusher dust, indicating that the degree of expansion changes from 'critical' to 'non critical' state.
3. There is marked reduction in Plasticity Index values (31.85% to 6.8%), if the BC soil is mixed lime and crusher dust.
4. The lime stabilized BC soil mixed with crusher dust changed the proctor compaction parameters. There is a decrease in OMC and increase in MDD with the increase of crusher dust in lime stabilized BC soil. It is observed

that when lime stabilized clay sample is mixed with 20% crusher dust the MDD increased from 1.58 g/cc to 1.81 g/cc with decrease in OMC from 22% to 14.3%.

All these results shows that there is significant improvement in the geotechnical characteristics of Black cotton Soil with the addition of crusher dust into it. The problematic property that is swelling is completely checked. The significant improvement in swelling behavior and stability characteristics of black cotton soil could be achieved by addition of crusher dust about 20% of dry weight of the black cotton soil mixed with 5% lime.

Based on the results of the experimental work it can be concluded that crusher dust has good potential to modify the engineering characteristic of expansive soil like black cotton soil. It is an eco-friendly and cost effective method for those areas where the weak soil exists and crusher dust is readily available in huge quantity as an industrial waste. This help to find the application of industrial waste to stabilize expansive weak soils and utilize them in many geotechnical applications like select soils for road subgrades, foundation soil, embankment, etc.

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