iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 4 Issue: V Month of publication: May 2016

DOI:

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www.ijraset.com
IC Value: 13.98

Volume 4 Issue V, May 2016
ISSN: 2321-9653

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Stabilization of Black Cotton Soil Using Waste Foundry Sand & Lime

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Abstract--Black cotton soil is one of the major soil deposits of India. They exhibit high swelling and shrinking when exposed to changes in moisture content and hence have been found to be most troublesome from engineering considerations. Stabilization occurs when WFS & lime is added to black cotton soil and a pozzolanic reaction takes place. The WFS & hydrated lime reacts with the clay particles and permanently transforms them into a strong cementious matrix. Black cotton soil showing low to medium swelling potential from collage campas Maharashtra was used for determining the basic properties of the soil. Changes in various soil properties such as Liquid limit, Plastic Limit, Maximum Dry Density, Optimum Moisture Content, Differential Free Swell, Swelling Pressure and California Bearing Ratio were studied.

I. INTRODUCTION

The seasonal moisture variations in expansive soil deposits around and beneath the structures lead to their subsequent upward and downward movements resulting into damages of varying degrees. Civil engineering structures such as highways, canals, and embankments occupy vast areas of land as they often stretch over several kilometers. Among various methods for the solutions to the problems posed by expansive soils, especially for large area coverage, the stabilization of such soils would be a natural choice. Stabilization of expansive soils using WFS & lime is widely adopted by practicing engineers the world over. The pozzolanic property of WFS & Lime makes it a potentially useful material especially in the civil engineering industry. Thus, there is a growing awareness among civil engineers to explore the possibility of beneficial utilization of this industrial waste material, which is available almost free of cost in India. Urbanization and growth in the economy of cities of India have led to the steep increase in the building construction activities and has necessitated the implementation of infrastructure projects such as highways, railways, air strips, water tanks, reclamation etc. As we know the development of the Nation is depends upon their infrastructure and road constructions. Proper highway networks contribute to give the boost to the Economic development of country. Wide range of soil types available as highway construction materials. Roads running in black cotton soils are known for bad condition and unpredictable behavior for which the nature of the soil contributes to some extent. The properties of the black cotton soils may be altered in many ways viz. mechanical, thermal, chemical and other means.

II. CHARACTERISTICS OF BLACK COTTON SOIL

Black Cotton soils are inorganic clays of medium to high compressibility and form a major soil group in India. Black Cotton soil has a high percentage of clay, which is predominantly montmorillonite in structure and black or blackish grey in color. Because of its high swelling and shrinkage characteristics, the Black Cotton soil has been a challenge to geotechnical and highway engineers. The soil is very hard when dry, but loses its strength completely when in wet condition (Balasubramaniam, et. al, 1989). The wetting and drying process causes vertical movement in the soil mass which leads to failure of a pavement, in the form of settlement, heavy depression, cracking and unevenness. It also forms clods which cannot be easily pulverized as treatment for its use in road construction (Holtz & Gibbs, 1956). This poses serious problems as regards to subsequent performance of the road. Moreover, the softened sub grade has a tendency to heave into the upper layers of the pavement, especially when the sub-base consists of stone soling with lot of voids. Gradual intrusion of wet Black Cotton soil invariably leads to failure of the road. However, since this soil is available easily at low cost, it is frequently used for construction purposes (Bell, 1988). Some of the factors which influence the behaviour of these expansive soils are initial moisture content, initial dry density, amount and type of clay, Atterberg limits of the soil, and swell potential.

III. FOUNDRY SAND STABILIZATION

Metal foundries use large amount of sand as part of metal casting process. Foundries successfully recycle and reuse the sand many times in a foundry. When the sand can no longer be reused in the foundry, it is removed from the foundry and is termed" Foundry Sand." Foundry sand is high- quality uniform silica sand that is used to make molds and cores for ferrous and nonferrous metal castings. Foundry sands typically comprise of >80% high-quality silica sand, 5-10% bentonite clay, 2-5% water and less than 5% sea coal. The metal casting industry annually uses an estimated 100 million tons of foundry sand for production. The physical and chemical characteristics of foundry sand will depend in great part on the type of casting process and the industry sector from which it originates.

IV. LIME STABILIZATION

Lime in the form of quicklime (calcium oxide – CaO), hydrated lime (calcium hydroxide – $Ca[OH]_2$), or lime slurry1 can be used to treat soils. Quicklime is manufactured by chemically transforming calcium carbonate (limestone –$CaCO_3$) into calcium oxide. Hydrated lime is created when quicklime chemically reacts with water. It is hydrated lime that reacts with clay particles and permanently transforms them into a strong cementitious matrix. Most lime used for soil treatment is "high calcium" lime, which contains no more than 5 percent magnesium oxide or hydroxide. On some occasions, however, "dolomitic" lime is used. Dolomite lime contains 35 to 46 percent magnesium oxide or hydroxide. Dolomite lime can perform well in soil stabilization The use of lime for stabilizing plastic montmorillonitic clays has been increasing in favor during the last few decades because it lowers volume change characteristics. Generally the amount of lime required to stabilize expansive soils ranges from 2 to 10% by weight. The addition of lime to clay soil provides an abundance of calcium ions (Ca2+) and magnesium ions (Mg2+). These ions tend to displace other common cations such as sodium (Na+) and potassium (K+), in a process known as cation exchange. Replacement of sodium and potassium ions with calcium significantly reduces the plasticity index of the clay.

V. OBJECTIVE OF PROPOSED WORK

In present experimental program the performance of Black Cotton Soil with Lime for the improvement in strength. The experimental program is planned to study the following objectives.

To study physical properties of Black Cotton Soil with Constant Percentage of WFS(20%) & varying percentage of lime from 0 to 10 %. To study the behavior of strength gain in BC soil using process of WFS & lime stabilization. Finding out optimize proportion of Soil-WFS-lime to achieve maximum strength.

VI. CALIFORNIA BEARING RATIO TEST (IS: 2720 (PART 16) 1979)

California Bearing Ratio (CBR) test was developed by the California Division of Highway as a method of classifying and evaluating soil-sub grade and base course materials for flexible pavements. CBR test, an empirical test, has been used to determine the material properties for pavement design. Empirical tests measure the strength of the material and are not a true representation of the resilient modulus. It is a penetration test wherein a standard piston, having an area of 50 mm diameter, is used to penetrate the soil at a standard rate of 1.25 mm/minute. The pressure up to a penetration of 12.5 mm and it's ratio to the bearing value of a standard crushed rock is termed as the CBR.

In most cases, CBR decreases as the penetration increases. The ratio at 2.5 mm penetration is used as the CBR. In some case, the ratio at 5 mm may be greater than that at 2.5 mm. If this occurs, the ratio at 5 mm should be used. The CBR is a measure of resistance of a material to penetration of standard plunger under controlled density and moisture conditions. The test procedure should be strictly adhered if high degree of reproducibility is desired. The CBR test may be conducted in re-molded or undisturbed specimen in the laboratory. The test is 111simple and has been extensively investigated for field correlations of flexible pavement thickness requirement.

$$CBR = \frac{load\ carries\ by\ specimen}{load\ carries\ by\ saturated\ specimen} \times 100$$

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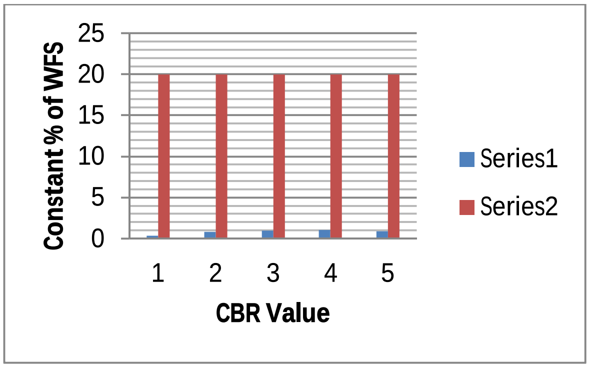
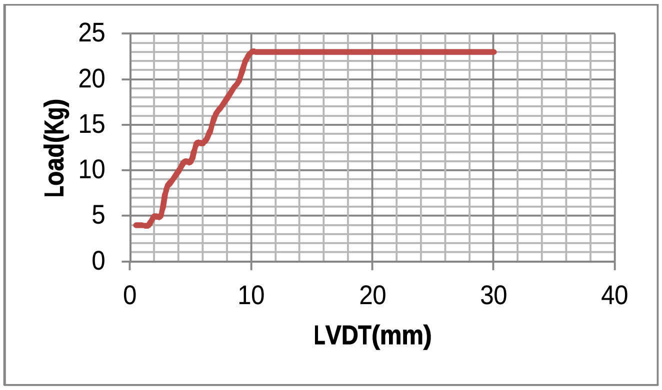
A. CBR Value v/s Percentage of WFS & Lime

Mix number	CBR Value	
	2.5mm	5mm
M00	0.36	0.52
M05	0.87	0.66
M10	1.00	0.72
M15	1.06	0.76
M20	0.93	0.67



B. California Bearing Ratio for M00

LVDT	LOAD	LVDT	LOAD	LVDT	LOAD
0.5	4	5.5	13	10.5	23
1	4	6	13	11	23
1.5	4	6.5	14	11.5	23
2	5	7	16	12	23
2.5	5	7.5	17	12.5	23
3	8	8	18	13	23
3.5	9	8.5	19	13.5	23
4	10	9	20	14	23
4.5	11	9.5	22	14.5	23
5	11	10	23	15	23



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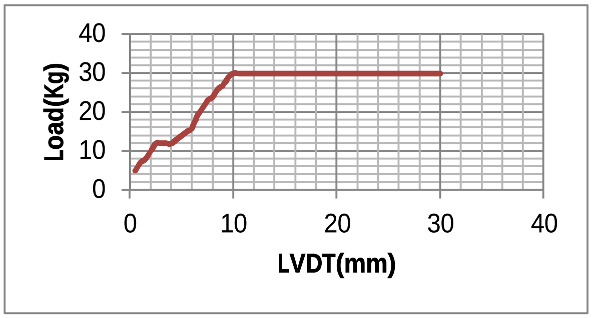
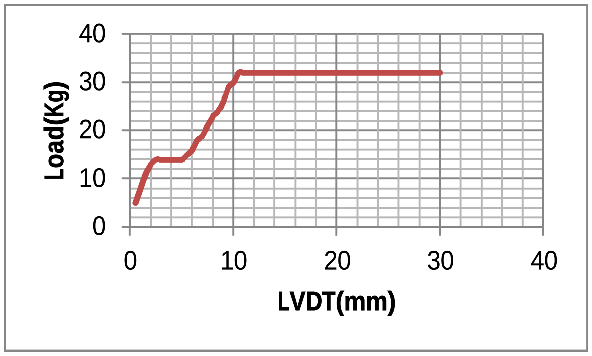
C. California Bearing Ratio for M05

LVDT	LOAD	LVDT	LOAD	LVDT	LOAD
0.5	5	5.5	15	10.5	30
1	7	6	16	11	30
1.5	8	6.5	19	11.5	30
2	10	7	21	12	30
2.5	12	7.5	23	12.5	30
3	12	8	24	13	30
3.5	12	8.5	26	13.5	30
4	12	9	27	14	30
4.5	13	9.5	29	14.5	30
5.0	14	10	30	15	30



D. California Bearing Ratio for M10

LVDT	LOAD	LVDT	LOAD	LVDT	LOAD
0.5	5	5.5	15	10.5	32
1	8	6	16	11	32
1.5	11	6.5	18	11.5	32
2	13	7	19	12	32
2.5	14	7.5	21	12.5	32
3	14	8	23	13	32
3.5	14	8.5	24	13.5	32
4	14	9	26	14	32
4.5	14	9.5	29	14.5	32
5	14	10	30	15	32



E. California Bearing Ratio for M15

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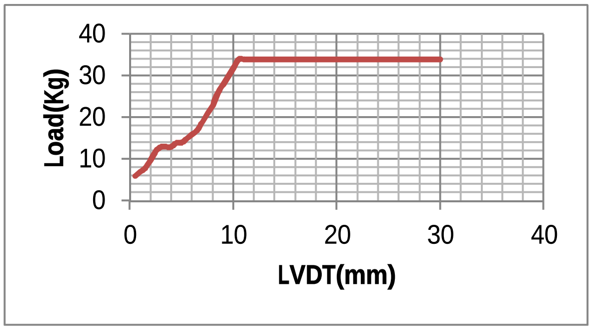
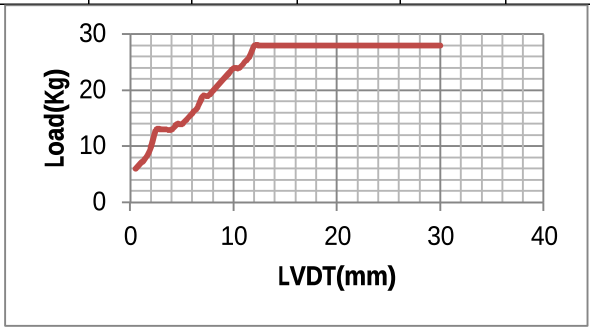
LVDT	LOAD	LVDT	LOAD	LVDT	LOAD
0.5	6	5.5	15	10.5	34
1	7	6	16	11	34
1.5	8	6.5	17	11.5	34
2	10	7	19	12	34
2.5	12	7.5	21	12.5	34
3	13	8	23	13	34
3.5	13	8.5	26	13.5	34
4	13	9	28	14	34
4.5	14	9.5	30	14.5	34
5	14	10	32	15	34



F. California Bearing Ratio for M20

LVDT	LOAD	LVDT	LOAD	LVDT	LOAD
0.5	6	5.5	15	10.5	24
1	7	6	16	11	25
1.5	8	6.5	17	11.5	26
2	10	7	19	12	28
2.5	13	7.5	19	12.5	28
3	13	8	20	13	28
3.5	13	8.5	21	13.5	28
4	13	9	22	14	28
4.5	14	9.5	23	14.5	28
5	14	10	24	15	28



VII. CONCLUSION

From the literature it appears that a number of stabilizers are available like WFS, lime, cement, lime and cement combinations etc. Through this experimentation it is concluded that the WFS & lime is good stabilizing compound. The main engineering properties of the black cotton soil can be improved by using WFS & lime. The following conclusions can be derived from the present investigation:

Waste Foundry Sand and Lime is beneficial in combination with OMC in improving properties of soil. With the Constant percentage of Waste Foundry sand and increase in the percentage of lime, strength tends to increase and reaches a certain maximum value and thereafter it starts decreasing.

Utilization of WFS & lime in this manner has the advantage of reusing an industrial waste by-product without adversely affecting the environment or potential land use.

The results show a considerable decrease in the liquid limit. Decrease in Liquid limit means there is decrease in permeability & increase in dry strength of black cotton soil.

With the increase in constant percentage of WFS & varying percentage of lime content, the maximum dry density of Soil-WFS-Lime mixes decreases and optimum moisture content increases.

The CBR value of the soil increases with the addition of of constant percentage of Waste Foundry Sand and varying percentage of lime.

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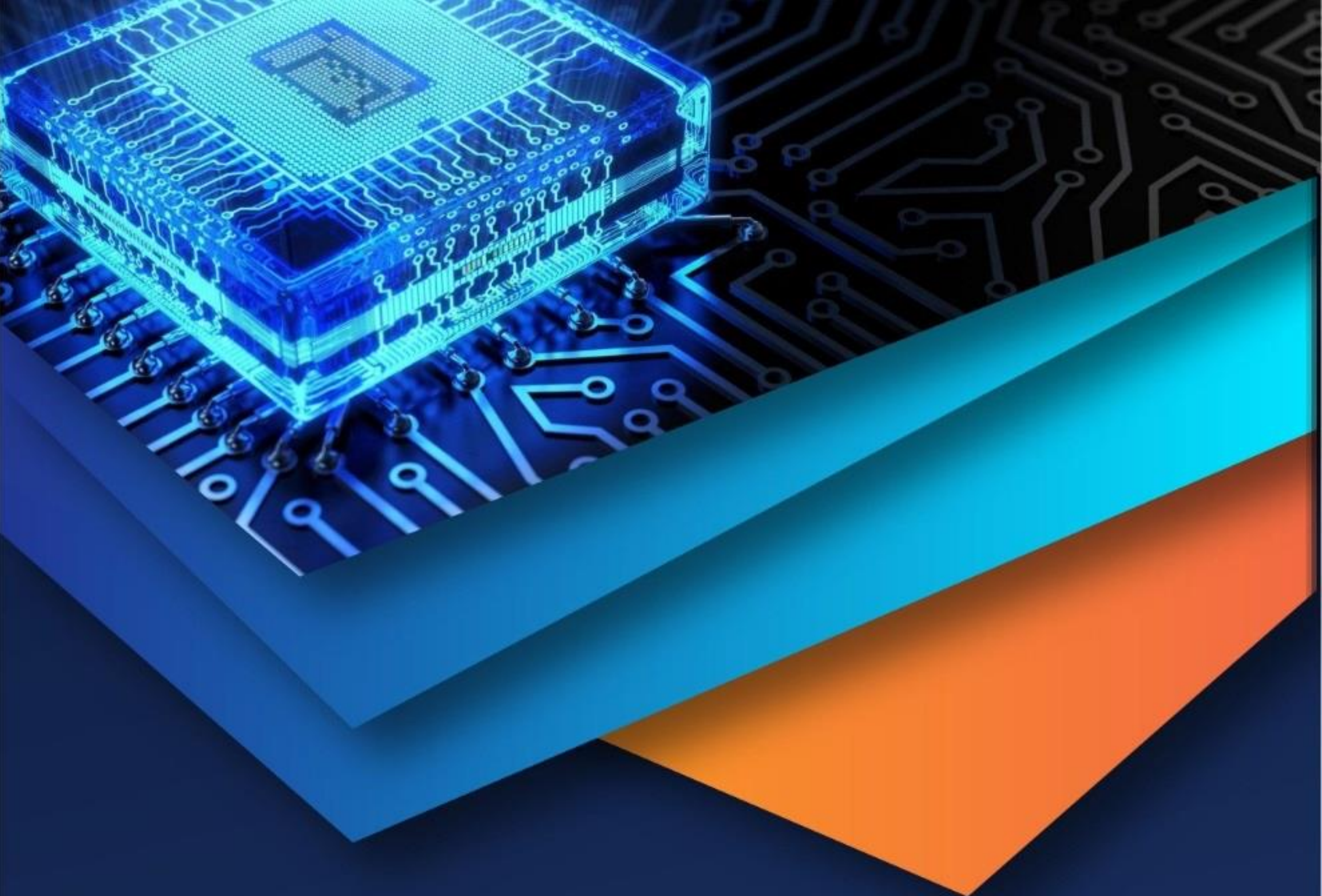

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