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Stabilization of Black Cotton Soil Using Envirobase and Sodium Silicate with Lime

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Abstract

Black cotton soil is a major type of soil in India. It constitutes one third of total area in India. Largest share of this soil is found in states like Maharashtra, Madhya Pradesh and Gujarat. This soil is well known for their high swelling and high shrinking properties. It is due to the clay Montmorillonite. They have very high water-holding capacity. This type of soil properties can by stabilized by adding chemicals envirobase, sodium silicate, lime, etc. We experimented with chemicals in different proportions to study their effect on soil to find the best economical material to be used for stabilization

Keywords— Envirobase, Soil, Sodium Silicate, Lime

I. INTRODUCTION:

A. Background:

The word “soil” is derived from the Latin word sodium which according to Webster’s dictionary. Soil is a mixture of minerals, organic matter, gases, liquids, and countless organisms that together support life on Earth. Soil is a natural body called the pedosphere which has four important functions: it is a medium for plant growth; it is a means of water storage, supply and purification; it is a modifier of Earth's atmosphere; it is a habitat for organisms; all of which, in turn, modify the soil. Soil is called the "Skin of the Earth”. Most soils have a density between 1 and 2 g/cm.

Black cotton soil is found in extensive region of Deccan Trap in Indian. They are of variable thickness, underlain by black sticky material known as “black soil”. Black cotton soil is when comes in contact with water it either swells or shrinks and resulting in moments to the structure which are generally not related to direct effect of loading. On account of its high volumetric changes it is not suitable for construction. It swells and shrinks excessively due to present of fine clay particles. Alternate swelling and shrinking of soil are responsible for differential settlement of structure so black cotton soil must be treated by using suitable admixtures to stabilize it. The stability and bearing power of the soil is considerably improved by soil stabilization through controlled compaction, proportioning and the addition of suitable admixtures Swelling soil is not suitable for the construction work on account of its volumetric changes. Expansive soil deposits occur in the arid and semi-arid regions of the world and are problematic to the engineering structures because of their tendency to heave during the wet season and shrink during dry season. Different damages in the form of cracking, undulation, differential settlements, etc. are experienced by the roads, buildings, irrigation canals, water and sewer lines, etc.

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Black cotton soils are very fertile soils, they are not good as road or construction foundation. Black cotton soils are expansive clays with high potential for shrinking or swelling as a result of changing moisture content. Due to intensive shrinks well processes, surface crack resulting in openings during dry seasons. These openings are usually more than 50mm wide and several millimetres deep. Cracks disappear during wet season but an uneven soil surface stays as a result of irregular swelling and heaving. The term ground improvement and ground modification refer to the improvement or modification to the engineering properties of soil that are carried out at a site where the soil in its natural state does not possess properties that are acceptable to us for the proposed Civil Engineering activity.

B. Aims and objectives:

The aims and objectives of this investigation is bringing stability for structure to be developed on black cotton soil. Adding strength to the black cotton soil below road and other structures so as to increase its lifespan by varying parameters as follows,

1. To find the bearing capacity by CBR test and moisture content of black cotton soil.
2. To improve soil strength and workability by using chemicals.
3. To find bearing capacity of chemical mixed black cotton soil by CBR test.
4. Compare the result of natural black cotton soil and chemical added black cotton soil.

II. REVIEW OF LITERATURE

Muzaffar Wani etc. [2017] In this paper we studied that improving the engineering properties of the soil by using sodium silicate with lime. This paper presents a review of different researchers in the recent years on the use of lime for improvement the strength, moisture content, and plasticity index of black cotton soil. It contains different percentage of addition of lime and then sodium silicate along with lime in soil, their effect on compressive strength and increase optimum moisture content. The compressive strength increased by 129% when addition of soil +4.5% lime +2.5% sodium silicate and when addition of soil + 4.5% lime +2.5% sodium silicate then CBR increased by 219%.

Pramod Kilabanur etc. [2015] In this paper we studied that improving the engineering properties of the soil by using envirobase. In this paper we observed that addition of envirobase to the black cotton soil had increase the CBR and reduced plasticity index of soil. This paper show that how effective Envirobase in case of roads, highway and airfield construction. In case use of envirobase in black cotton soil the CBR value increased by more than 250% and optimum moisture content reduced to 12% when 3% envirobase was added to the soil.

Hossein Moayedi etc. [2011] In this paper Soft clay soil can be stabilized by the adding of small percentages of sodium silicate. Addition of 5mol/L sodium silicate showed the highest unconfined compressive strength. Clay soil presents problems to geotechnical engineers because of its complex nature like low hydraulic conductivity, its plasticity, and therefore the time dependency of volume as well as pore water pressure change. In this paper unconfined compressive strength test is conducted.

Shailendra Singh etc. [2015] In this paper Black Cotton soil is one which when associated with engineering structure and in presence of water will show a tendency to swell or shrink. Black cotton soil is not suitable for the construction work on account of its volumetric changes. Black cotton soil is made of varying properties of clay minerals like Montmorillonites, Illite and Kaolinite, chemicals like iron oxide and calcium carbonate in.

III. PROBLEM FORMULATION

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Alternate swelling and shrinkage of soil is responsible for differential settlement, crack etc. causes in the structures are experienced by the road, building, irrigation canal etc. And at worst case failure of structure will occurs.

IV. METHODOLOGY

A. *Material used:*

1.Black cotton soil: The laboratory tests were conducted to determine various engineering and physical properties of the soil. According to IS:1498-1970 classification system of the soil was clayey soil.

2. Envirobase: Envirobase is a liquid soil strengthener for the installation of durable, virtually weatherproof unpaved roads and exceptionally strong, long lasting bases for paved roads. It is a unique blend of environmentally safe, non-toxic compounds that, when properly applied, allows the construction of a durable, strong, virtually water-resistant soil layer via an ionic stabilization process.

properties of Envirobase:

Table Number 1: properties of Envirobase

Sr. No.	**Particulars**	**Values**
1	Appearance	Translucent liquid
2	Odor	None of slightly chemical odor
3	pH	11-12
4	Vapor Pressure	N/A
5	Flammability	Non flammable
6	Specific Gravity	1.33
7	Oxidizing properties	No
8	Solubility	100% in water
9	Vapor density	N/A
10	Freezing point	>32 F
11	Boiling point	>212 F

3. Sodium Silicate: Sodium silicate is a generic name for chemical compounds with the formula NaSiO or (Na2O)·SiO such as sodium metasilicateNa2SiO3, sodium orthosilicateNa4SiO4, and sodium pyro silicateNa6Si2O7.The anions are often polymeric. These compounds are generally colourless transparent solids or white powders, and soluble in water in various amounts.

4. Lime: Lime is the common name of chemical calcium oxide which is available in white powder form and comes from the heating of calcium carbonate. Lime is a calcium-containing inorganic mineral composed primarily of oxides, and hydroxide, usually calcium oxide and calcium hydroxide. It is also the name for calcium oxide which occurs as a product of coal seam fires and in altered limestone xenoliths in volcanic ejecta. The word lime originates with its earliest use as building mortar and has the sense of sticking or adhering.

Properties of Lime:

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Sr. No.	Particulars	Values
1.	Appearance	White to pale yellow/ brown powder
2.	Odour	Odourless
3.	Density	3.44 g/cc
4.	Melting point	2886 k
5.	Boiling point	4120 k

Table Number 2: properties of Lime

Test:

1. Oven Drying Method:

Determining Water Content in Soil by Oven Drying Method. This test is done to determine the water content in soil by oven drying method as per IS: 2720 (Part II) – 1973. The water content (w) of a soil sample is equal to the mass of water divided by the mass of solids.

2. Liquid Limit Test:

This section describes the laboratory procedure for determining the liquid limit of soils using the device specified in Section 3.8, securing the results of at least three trials, and the plotting of a flow curve.

3. Plastic Limit Test:

This section describes the laboratory procedure for determining the plastic limit of soils. The results of two trials must be obtained for averaging. This method is based upon AASHTO Designation T90 which has been modified for New York State Department of Transportation use.

4. California Bearing Ratio:

California bearing ratio is the ratio of force per unit area required to penetrate into a soil mass with a circular plunger of 50mm diameter at the rate of 1.25 mm /min.

V. RESULT

Table no 3: For sample pattern

Sr. No.	Sample Name	Sample Contents
1	Sample - A	Black Cotton Soil
2	Sample – B	Black Cotton Soil + 1 % Sodium Silicate + 2 % Lime
3	Sample – C	Black Cotton Soil + 2 % Sodium Silicate + 4 % Lime
4	Sample - D	Black Cotton Soil + 3 % Sodium Silicate + 6 % Lime
5	Sample – E	Black Cotton Soil + 1 % Envirobase
6	Sample – F	Black Cotton Soil + 2 % Envirobase
7	Sample – G	Black Cotton Soil + 3 % Envirobase

1.Liquid Limit Test:

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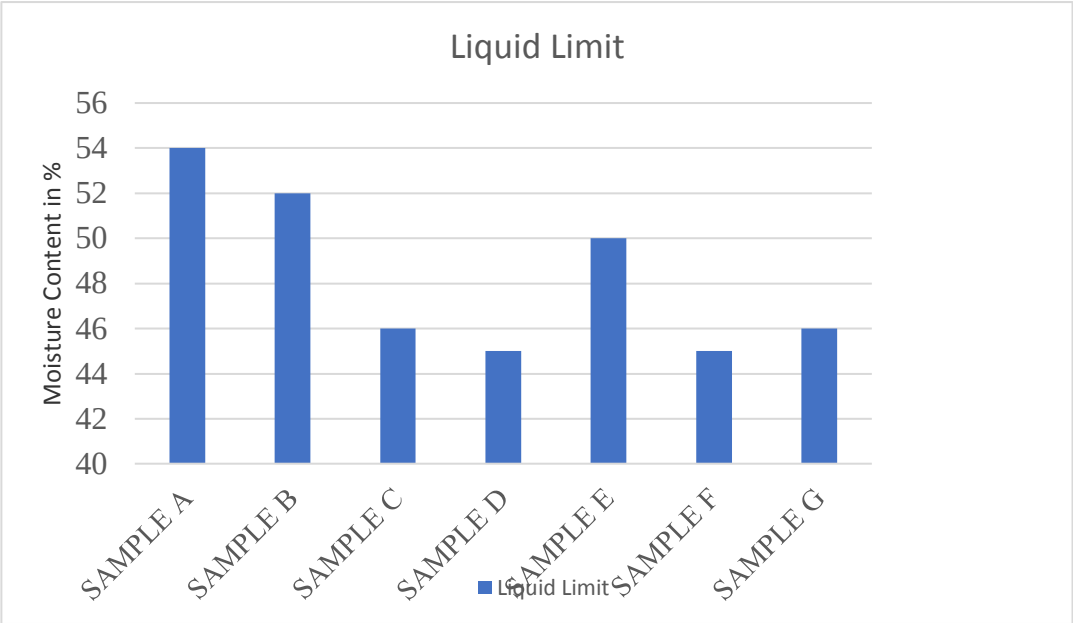
Table no 4: Liquid Limit Test Result

Sr. No.	Sample Name	Liquid Limit
1	Sample - A	54
2	Sample – B	52
3	Sample – C	46
4	Sample - D	45
5	Sample - E	50
6	Sample - F	45
7	Sample - G	46



Graph No.1 Results of Liquid Limit Test

On the basis of experimental test results, it is observed that the value of the Liquid Limit of plane black cotton soil i.e. Sample-A is greater value as that of the Sample B, C, D, E, F & From the above graph it is clear that the, If we increasing the % of Sodium Silicate With lime & Envirobase in black cotton soil it reduces the Liquid Limit of that soil.

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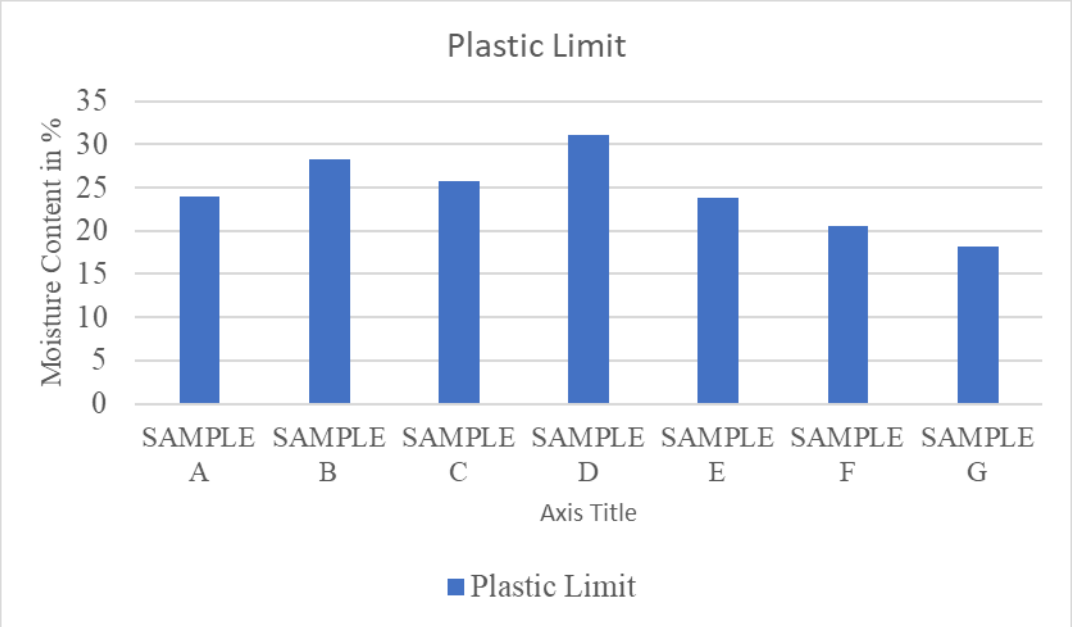
2. Plastic Limit Test:

Table No 5: Plastic Limit Test Result

Sr. No.	Sample Name	Plastic Limit
1	Sample - A	24.02
2	Sample – B	28.25
3	Sample – C	25.79
4	Sample - D	31.03
5	Sample - E	23.81
6	Sample - F	20.6
7	Sample - G	18.17



Graph No. 2 Results of Plastic Limit Test

On the basis of experimental test results, it is observed that the value of the plane black cotton soil i.e. Sample-A is lesser value as that of the Sample B, C & D but the Value of Sample A is greater than Samples E, F & G. From the above graph it is clear that the, If we increasing the % of Sodium Silicate with lime in black cotton soil it increases the Plasticity of that soil and if we increases the % of Envirobase in black cotton soil it reduces the plasticity of the soil.

3. Plasticity Index:

It is the boundary between liquid limit and plastic limit

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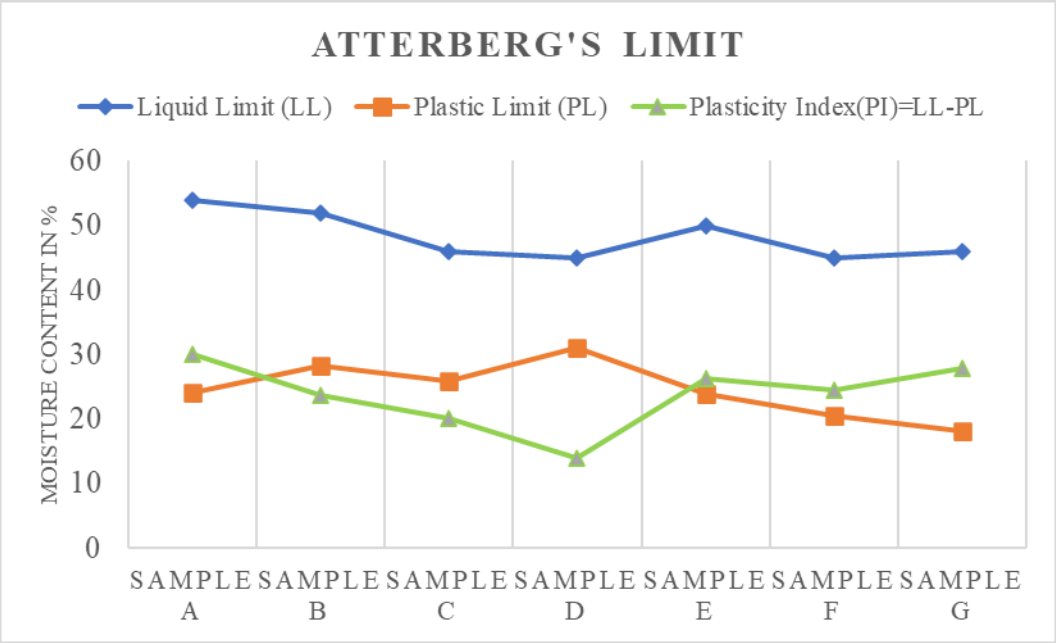
Table No 6: Plasticity Index of Given Soil Sample Result

Sr. No.	Sample Name	Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI) PI=LL – PL
1	A	54	24.02	29.98
2	B	52	28.25	23.75
3	C	46	25.79	20.21
4	D	45	31.03	13.97
5	E	50	23.81	26.19
6	F	45	20.6	24.4
7	G	46	18.17	27.83



Graph No.3 Results of All Limit Test

The green line shows the boundary of the soil between the solid states to liquid state.

4. California Bearing Ratio:

Table No 7: California Bearing Ratio Test Result

Sr. No.	Sample Name	California Bearing Ratio (%)
1	Sample-A	1.26
2	Sample-B	1.70
3	Sample-C	1.89
4	Sample-D	2.18
5	Sample-E	2.67
6	Sample-F	3.78
7	Sample-G	5.29

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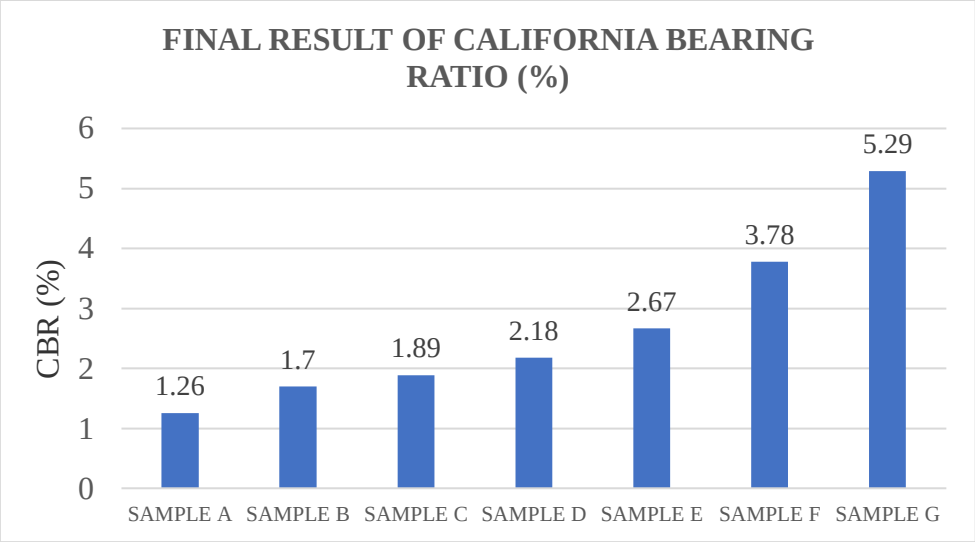

Graph No.4 Results of California Bearing Ratio Test

On the basis of experimental test results, it is observed that the value unconfined compressive strength of the plane black cotton soil i.e. Sample-A is less value as that of the Sample B, C, D, E, F & G. From the above graph it is clear that the, if we increasing the % of Sodium Silicate with lime & Envirobase in black cotton soil its increase in California Bearing ratio of that soil and gives the denser medium of hard surface.

VI. CONCLUSIONS

From the analysis of this results following conclusions are drawn:

1. Liquid limit of the soil will be decrease if we increase Sodium Silicate with lime & Envirobase in Black Cotton Soil if we add 1%, 2% and 3% Sodium Silicate with 2%,4%, & 6% of lime and another sample we added 1%, 2% & 3% of Envirobase. It reduced limit 0%, 1% and 2% respectively, from original soil liquid limits.
2. Plastic limit of the soil sample will be increase when we add 1%, 2% & 3% of Sodium Silicate With 2%, 4% & 6% of lime separately in soil and the result we get are 28.25%, 25.79% & 31.03% respectively. When we add the 1%, 2% & 3% of Envirobase in black cotton soil it decreases plastic limit and the results are 23.81%, 20.6% & 18.17% respectively.
3. California Bearing Ratio values show the amount of increment when Sodium Silicate with lime and Envirobase is added to the black cotton soil. Gives the denser medium of hard surface.

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