

# Stabilization Of Black Cotton Soil Using Envirobase And Sodium Silicate With Lime

Pramod Kilabanur, Tanveer Ahmad, Dorothy Bhagabati, Nitesh Kumar, Yasaswini S

**Abstract:** Soil stabilization is a term used for improving mechanical, chemical, physical, biological or combined method to improve the properties of natural soil and making it fit for engineered purpose. This research is focused to evaluate the suitability of Envirobase and Sodium Silicate with lime on some of the geotechnical properties of black cotton soil obtained from Azadpur, Gulbarga located at northern region of Karnataka. The properties include Index properties and Strength properties such as compaction and California bearing ratio. It was observed that addition of Envirobase to the black cotton soil had increased the California bearing ratio by a remarkable amount and the addition of sodium silicate with lime reduced plasticity index of the soil.

**Keywords:** Black cotton soil, California bearing ratio, Envirobase, Lime, plasticity index, sodium silicate, soil stabilization

## 1 INTRODUCTION

Over the past few decades several factors have led to an increase in the number of people migrating to large cities. Consequently these large cities are getting over populated and quite expectedly necessity of business, residential construction has increased the civil engineering projects located in areas with unsuitable soil is one of the most common problems in many parts of the world. The unsuitable soil (Black cotton Soil) can be stabilized by performing soil stabilization. In India black soil is the most problematic soil when it comes to construction. In rainy season black cotton soil swells and become sticky. Whereas in summers the moisture present in the soil evaporates and soil shrinks resulting in the crack of approximate 10 to 15 cm wide and up to 1 meter deep. The percentage covered by black cotton soil in geotechnical areas of India is 16.6%, which says huge amount of soil in India needs stabilization. Mechanical, chemical, electrical, thermal and other methods are in practice to improve the engineering properties of soil. Chemical stabilization is the best method used for highways and airfield construction. This paper shows the results of chemical stabilization of black cotton soil, where the chemicals used are Envirobase and sodium silicate with lime. Experiments for index properties, compaction and CBR were conducted by adding different percentages of chemicals. The experiments were carried out by adding 1%, 2% and 3% of Envirobase and with dry weight of soil. In case of lime the percentage were taken as 2%, 4% and 6% with and the amount of sodium silicate is taken as half lime with dry weight of soil.

## 2 LITERATURE REVIEW

As per our analysis currently not much work has been done using Envirobase as a soil stabilizer. It is a newly grooming product in the field of construction and this paper shows that how effective Envirobase is in case of roads, highways and airfields construction

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**Evans.P** in 1998 stated that Lime stabilization causes a significant improvement in soil texture and structure by reducing plasticity and by providing pozzolanic strength gain. A significant level of long-term strength improvement in lime stabilized soils and aggregates is possible and probable. This level of strength improvement can meet typical specifications required by various user agencies. This strength improvement has been verified not only by extensive laboratory testing but also extensive field testing. These tests define that, when lime is added to a reactive soil or aggregate, strengths in excess of about 1,400 kPa are expected. This strength level has been identified as one that provides significant structural benefit to the pavement.

**Basma and Adnan A** in 1991 explained that, an evaluation of the soil-lime system for two soils typical of the highly expansive soils existing in Irbid city in northern Jordan is presented. The lime was added to the soils at 0 to 9 or 12%. The soil-lime specimens were cured for 1 hour, 7 days, and 28 days, after which they were subjected to laboratory tests. The properties obtained were the grain size distribution, consistency limits, chemical composition, swell potential, swell pressure, compression and rebound indices, rate of swell and consolidation, immediate settlement, and primary consolidation as percent of total settlement. Generally, lime is found to be most effective in stabilizing heave and settlement of expansive clays.

**Hossein Moayed, Bujang B.k. Huat, Faleh Moyadi, Afshin Asadi and Alireza Parsaie** in 2011 explained that soft clay soil can be stabilized by the adding of small percentages, by weight, of sodium silicate, thereby producing an improved construction material and enhancing many of the engineering properties of the soil. In order to explain such improvements, one of the most frequently occurring minerals in clay deposits, namely, kaolinite was subjected to a series of tests. As sodium silicate stabilization is most often used in relation to construction, the tests were chosen with this in mind. As results, addition of 5mol/L sodium silicate showed the highest unconfined compressive strength (UCS) results. However the effect of chemical molarities on UCS become less and less, with longer curing time.

**Harold Bernard Ellis** in 1963 conclude that calcilate lime sodium metasilicate pentahydrate when employed under optimum conditions are effective soil stabilizers of variety of soil ranging from a clean, uniformly graded dune sand

montmorillonitic clay of high plasticity.

### 3 MATERIALS AND METHODS

**Soil-** Black cotton soil was obtained from Azadpur, Gulbarga, Karnataka. The soil was taken from 1 meter below the ground level. Below table shows the test results which were carried out to determine the properties of the soil.

**Table 1** (Properties of black cotton soil)

S.no	Laboratory test	Results
1	Grain size distribution	82.6% fine (well graded sand)
2	Specific gravity	2.5
3	Moisture content	19.54%
4	Liquid limit	51%
5	Plastic limit	27.09%
6	Plasticity index	23.91%
7	Shrinkage limit	19%
8	Maximum dry density	15.19 kN/m <sup>3</sup>
9	Optimum moisture content	30%
10	California bearing ratio	1.43%

**Envirobase-** Envirobase is liquid material with acts as asoil stabilizer and was bought from JS Water energy life co. Pvt. Ltd New Delhi. Below are the properties of Envirobase.

**Table 2** (Properties of Envirobase)

1	Appearance	Translucent liquid
2	Odor	None to slightly chemical odor
3	p <sup>H</sup>	11-12
4	Vapor pressure	N/A
4	Flammability	Non flammable
5	Specific gravity	1.33
6	Oxidizing properties	No
7	Solubility	100% in water
8	Vapor density	N/A
9	Freezing point	>32 °f
10	Boiling point	>212 °f

**Sodium silicate-** Sodium silicate is compound belongs to sodium metasilicate family. Commonly known as water glass or liquid glass. The appearance of the chemical is in crystal form but it is generally available as aqueous solution.

**Table 3** (Properties of sodium silicate)

S.no	Particulars	Values
1	Totally alkaline (Na <sub>2</sub> O <sub>3</sub> )	11.03
2	Silicate (SiO <sub>2</sub> )	28.57
3	Ratio by weight Na <sub>2</sub> O, SiO <sub>2</sub>	1 to 2.43
4	Molecular ratio Na <sub>2</sub> O, SiO <sub>2</sub>	1 to 1.66

**Chemical reaction for Sodium silicate-Na<sub>2</sub>CO<sub>3</sub> + SiO<sub>2</sub> → Na<sub>2</sub>SiO<sub>3</sub> + CO<sub>2</sub>**

**Lime-** lime is the common name of chemical calcium oxide which is available in white power form and comes from the heating of calcium carbonate. Chemical reaction for lime **CaCO<sub>3</sub> on heating Cao + CO<sub>2</sub>**

**Table 4** (Properties of lime)

S.no	Particular	Values
1	Appearance	White to pale yellow/ brown powder
2	Odor	Odorless
3	Density	3.44 g/cc
4	Melting point	2886 k
5	Boiling point	4120 k

**Test procedure-** All the test for specific gravity, Atterbergs limit, compaction and California bearing ratio were conducted as per relevant IS code.

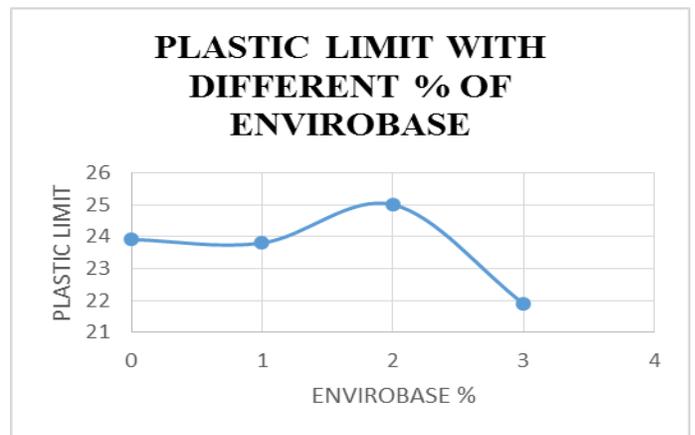
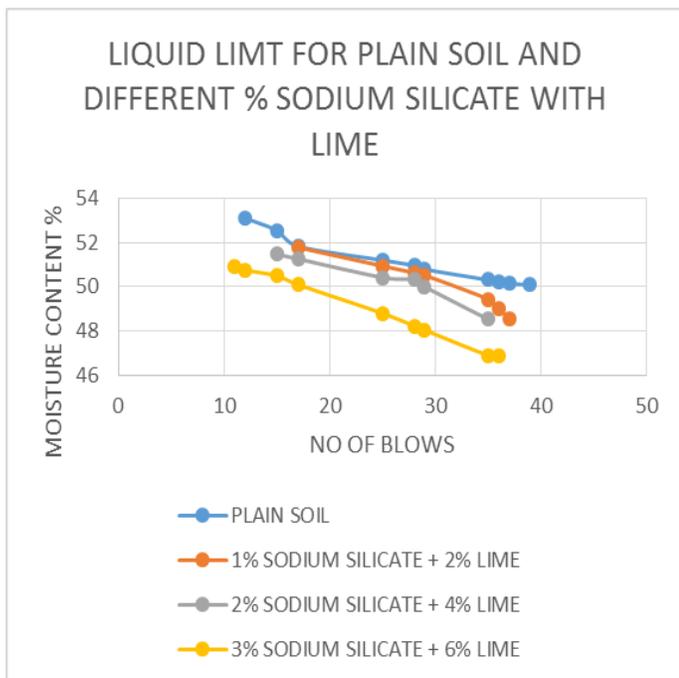
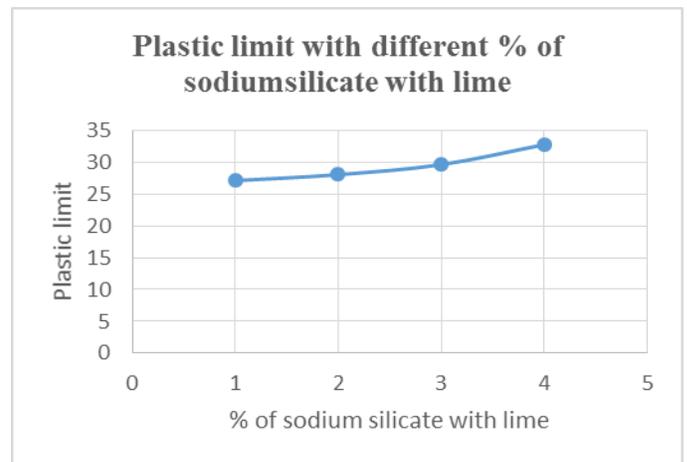
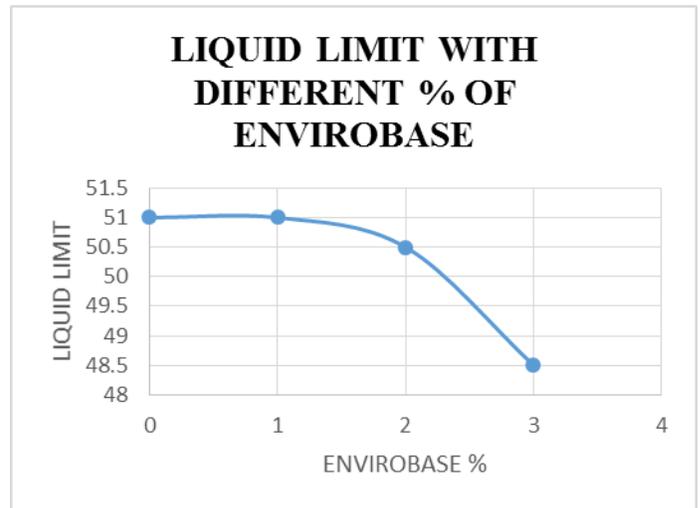
### 4 RESULTS AND DISCUSSION

Atterberg limits, specific gravity, compaction and California bearing ratio test were carried out as per IS 2720 guidelines for stabilized soil sample. Different percentages of Envirobase and sodium silicate with lime were taken to determine the test values. The table below shows the values of the test with different percentages of chemical added to black cotton soil.

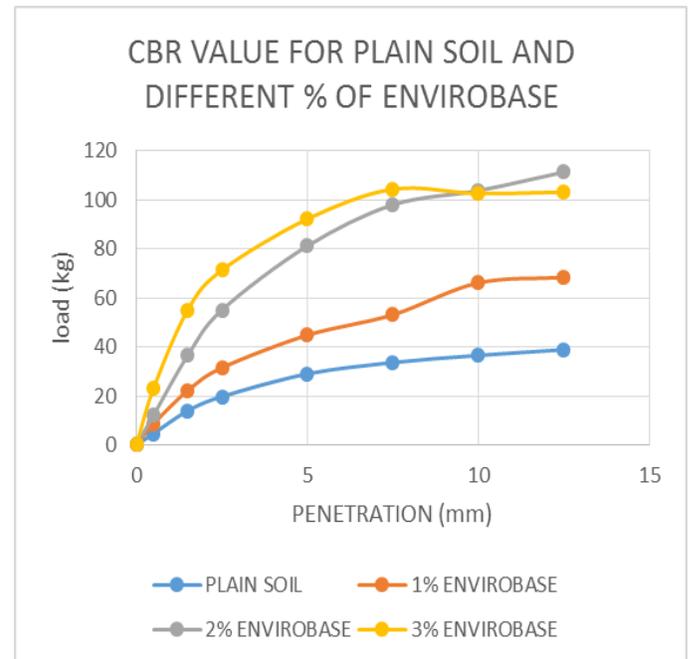
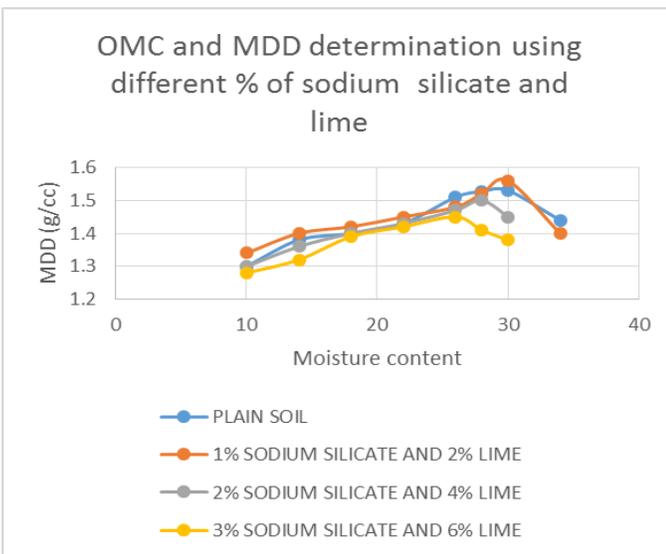
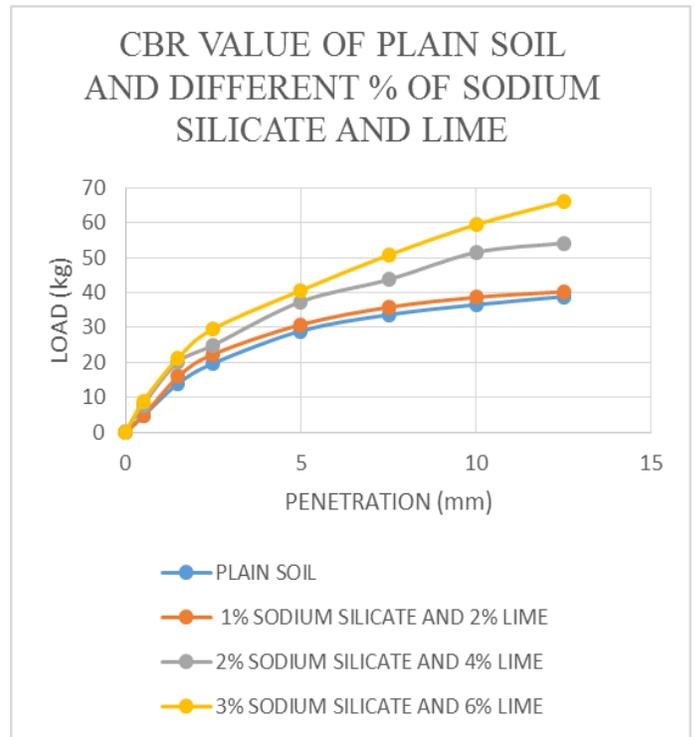
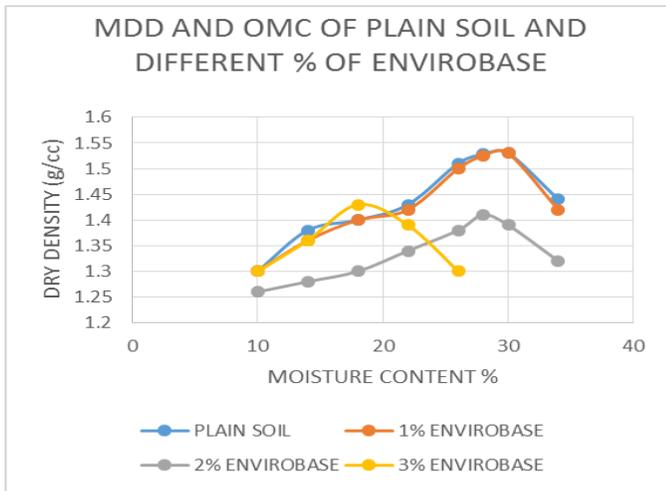
S.no	Laboratory test	%Envirobase in soil	%Sodium Silicate in soil	% Lime in soil	Values
1	Specific gravity	1%	-	-	3.73
2	Specific gravity	2%	-	-	2.64
3	Specific gravity	3%	-	-	2.30
4	Specific gravity	-	1%	2%	2.47
5	Specific gravity	-	2%	4%	2.63
6	Specific gravity	-	3%	6%	2.8
7	Liquid limit	1%	-	-	51%
8	Liquid limit	2%	-	-	50.5%
9	Liquid limit	3%	-	-	48.5%
10	Liquid limit	-	1%	2%	50.73%
11	Liquid limit	-	2%	4%	50%
12	Liquid limit	-	3%	6%	48.8%6
13	Plastic limit	1%	-	-	23.8%
14	Plastic limit	2%	-	-	25%
15	Plastic limit	3%	-	-	21.9%
16	Plastic limit	-	1%	2%	28.02%
17	Plastic limit	-	2%	4%	29.60%
18	Plastic limit	-	3%	6%	32.73%
19	Shrinkage limit	1%	-	-	19%
20	Shrinkage limit	2%	-	-	18%
21	Shrinkage limit	3%	-	-	15.6%

22	Shrinkage limit	-	1%	2%	19%
23	Shrinkage limit	-	2%	4%	18.24%
24	Shrinkage limit	-	3%	6%	18.76%
25	OMC	1%	-	-	30%
26	OMC	2%	-	-	27%
27	OMC	3%	-	-	18%
28	OMC	-	1%	2%	30%
29	OMC	-	2%	4%	28%
30	OMC	-	3%	6%	26%
31	MDD	1%	-	-	14.70kN/m <sup>3</sup>
32	MDD	2%	-	-	13.72kN/m <sup>3</sup>
33	MDD	3%	-	-	13.62kN/m <sup>3</sup>
34	MDD	-	1%	2%	15.3kN/m <sup>3</sup>
35	MDD	-	2%	4%	14.81kN/m <sup>3</sup>
36	MDD	-	3%	6%	14.22kN/m <sup>3</sup>
37	CBR	1%	-	-	2.01%
38	CBR	2%	-	-	4.09%
39	CBR	3%	-	-	5.20%
40	CBR	-	1%	2%	1.62%
41	CBR	-	2%	4%	1.82%
42	CBR	-	3%	6%	2.01%

**Atterberg limits-** As shown in table 5 consistency limit varies with varying percentages of chemical stabilizers liquid limit reduces by the addition of Envirobases and sodium silicate with lime in all percentages but the maximum reduction is at 3% addition of Envirobases. Plastic limit reduces by the addition of Envirobases. In case of sodium silicate and lime plasticity increases which results in the reduction of plasticity index. Much reduction has been seen in shrinkage limit when Envirobases are added with respect to sodium silicate with lime.



**Compaction-** The test was carried out by adding different percentages of Envirobases, sodium silicate and lime. Addition of chemicals with soil reduce the optimum moisture content, the maximum reduction seen in the optimum moisture content is at 3% addition of Envirobases, where OMC reduced by 12% from 30% to 18%. In the case of maximum dry density it also reduced which should have increased from the maximum dry density of the natural soil. In addition of 1% of Envirobases in the natural soil, optimum moisture content and maximum dry density showed no change. In case of sodium silicate with lime also OMC and MDD remained same but further addition of the chemical reduces the OMC and MDD values.



**California bearing ratio-** As given in the table CBR value of the soil showed huge increment when chemical stabilizer added to the soil, specifically in case of Envirobase CBR value increase by more than 250% when 3% Envirobase was added to the soil. In case of sodium silicate and lime CBR increased as well. Below graphs shows the comparison in CBR values in addition of different percentages of chemical stabilizer with plain soil. Maximum CBR values were obtained at 2.5mm penetration in all the cases.

**5 CONCLUSION**

- Liquid limit decreases in the addition of sodium silicate with lime. The addition of 1% Envirobase liquid limit remains constant then reduces after further increment in Envirobase percentage.
- Sodium silicate with lime reduces the plasticity index and holds good in case of consistency limits.
- Envirobase reduces the optimum moisture content by a remarkable amount and reduce maximum dry density also.
- California bearing ratio values show huge amount of increment when Envirobase is added to the soil.
- Sodium silicate with lime can be used as local

stabilizer in small construction works, as it is cheap and easily available. For Envirobase usage construction project should be large and in case of highways and airfield construction Envirobase is one the best soil stabilizer.

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