

Laboratory Performance of RBI 81 Stabilized Soil for Pavements

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Abstract

In this study a new Proprietary Cementitious Stabilizer (RBI Grade 81) is being used to study the improvement in engineering properties of Black Cotton (BC) soil. The collected soil samples were treated with RBI 81 in various mix ratios. Subsequently, the treated soil samples were cured for different periods ranging from four hours to twenty eight days. The engineering properties obtained for different mix proportions of soil and the stabilizer are studied. The results of Unconfined Compressive Strength (UCS) test, California Bearing Ratio (CBR) test and Fatigue Life test obtained for different mix proportions of soil and stabilizer, for different curing periods under soaked and unsoaked conditions have been studied and discussed. Tests were also conducted to determine chemical composition of untreated and treated soils to understand the mechanism of stabilization. Soaked CBR test results indicate that the stabilizer used works well with cohesive soils (such as BC soils). Fatigue life test results indicate a high fatigue life for all treated soils when subjected to repeated loading (considering 1/3rd UCS strength values) as compared to the untreated soils.

Keywords: Soil Stabilization, RBI 81, Black Cotton, UCS, CBR, Fatigue Life.

1. Introduction

Stabilization of soils with low-bearing capacity is an economical way to strengthen the earth for construction purposes. Engineers are often faced with the problem of constructing facilities on or with soils, which do not possess adequate strength to

support the loads imposed upon them either during construction or during the service life of the structure. Geiman (2005) used a set of traditional and non-traditional stabilizers including quicklime, hydrated lime, pelletized lime, cement, lignosulfonate, synthetic polymer, magnesium chloride, and a Proprietary Cementitious Stabilizer, RBI 81 against three Virginia soils that have caused problems during construction or resulted in poor performance in service. Shankar et al. (2008) reported that the presence of Pond ash in laterite soil improved the strength properties and resistance to moisture susceptibility and also resulted in the reduction of Maximum Dry Density (MDD) of blend with slight increase in the Optimum Moisture Content (OMC). RAASTA (2008) conducted laboratory studies on properties of soils treated with Proprietary Cementitious Stabilizer. In their study they selected four different types of SC soils and obtained substantial increase in CBR value (to 20% with 2% stabilizer). The increase and rate of increase in compressive strength of stabilized soil samples (after 7 days curing) with increasing stabilizer content was not substantial. Hence it was concluded that low percentages about 1-2% of stabilizer is effective to improve the properties of such clayey soils. Anitha et al. (2009) reported the optimum stabilizer percentage for red soil, laterite and kaolinite was observed as 4%, 2% and 6% respectively. The study revealed that both unsoaked and soaked CBR increased significantly with the addition of RBI Grade 81 for kaolinite, red soil and lateritic soil. Bhuyan (2010) conducted a study using industrial wastes blast furnace slag (BFS) and fly ash. Strength, bearing capacity, volume stability and durability were increased by the method of stabilization using lime and proprietary cementitious stabilizer. The aim of the paper is to study the geotechnical properties of stabilized and unstabilized BC soil.

2. Experimental Investigations

2.1 Materials used

Soils: The samples of BC soil were taken from 2m depth below the ground surface.

Stabilizer: A Proprietary Cementitious Stabilizer named RBI 81 (Road Building International 81) was used to enhance the BC soil. It is a powder additive which acts on soil to reduce voids between soil particles and to minimize absorbed water in the soil to achieve maximum compaction. The stabilizer is applied to the natural soil by loose volume and dry mass of the soil respectively. The properties of RBI 81 are tabulated in Table 1.

Table 1: Properties of RBI 81.

Property	Description
Odour	Odourless
pH	12.5
Specific Gravity	2.5
Solubility	In water (0.2 pts/ 100 pts)
Freezing Point	None, Solid

Flammability	Non-flammable
Shelf Life	12 months (dry storage)
Bulk density	700/m ³

2.2 Basic Tests

The basic tests performed includes test for Specific Gravity (IS:2720, Part-III), Atterberg's limits (IS:2720, Part-V), Compaction characteristics (IS:2720, Part-VII), Grain Size distribution (IS:2720,Part-IV), UCS (IS:2720, Part-X), CBR (IS:2720 Part-VI).The geotechnical properties of soils tested in the laboratory are tabulated in Table 2.

Table 2: Geotechnical properties of soil.

Sl. No	Property	BC soil
1	Specific gravity	2.58
2	Grain size distribution (%)	
	Gravel	1.3
	Sand	24.0
	Silt	52.0
	Clay	23.0
3	Consistency limits (%)	
	Liquid limit	53
	Plastic limit	23
	Plasticity index	30
4	IS soil classification	MH
	IS Light Compaction	
	a) MDD (kN/m ³)	15.50
	b) O.M.C %	31.00
	IS Heavy Compaction	
	a) MDD (kN/m ³)	17.46
	b) O.M.C %	20.00
5	CBR Value (%)	
	IS Heavy Compaction	
	a) OMC condition	7.0
	b) Soaked condition	0.3
6	UCS for IS Heavy Compaction (kN/m ²)	
	a) For OMC and MDD	380
	b) For 95% compaction on dry side	350
	c) For 95% compaction on wet side	300

3. Results and Discussions

3.1 Compaction Test Results

From Table 3 it is observed that, with the increase in percentage of stabilizer, the MDD of the soil decreases gradually, but it is only marginal. The OMC shows slight increase for 2% stabilizer and then shows gradual decrease with higher percentages of the stabilizer.

Table 3: Heavy Compaction test results for treated soil.

Soil - Stabilizer mix proportion (%)	BC soil	
	MDD (kN/m ³)	OMC (%)
100-0	17.46	20.00
98-2	17.80	21.00
96-4	17.60	18.00
94-6	17.20	16.00

3.2 Effect of RBI 81 on UCS

For unsoaked condition, the trend in strength shows a decrease for a curing period of one day and there after increase in strength with curing period. For curing period up to one day, the strength is practically zero by which soil treated with up to 2% stabilizer collapsing under its own weight. Further increase in curing period shows some increase in strength. Test results are depicted in Table 4.

Table 4: UCS Test Results for Treated Soils.

Curing Period (Days)	a) UCS strength in kN/m ²					
	b) 2% stabilizer		c) 4% stabilizer		d) 6% stabilizer	
	e) Unsoaked	f) Soaked	g) Unsoaked	h) Soaked	i) Unsoaked	j) Soaked
k) 4 hours	342	000	453	000	500	000
l) 1day	265	000	380	045	475	080
m) 3 day	460	100	620	150	740	190
n) 7 days*	600	080	980	210	1250	300
o) 28days*	830	140	1350	370	1800	680

*Soaking period of 1 day

2.5 Effect of RBI 81 on CBR

The CBR value after 7 days moist curing and 4 days soaking is observed with the increase in percentage of stabilizer. The results of the CBR tests are tabulated in Table 5.

Table 5: CBR test results for treated soils under IS Heavy Compaction.

Test property	% stabilizer			
	0	2	4	6
MDD (kN/m ³)	17.46	17.80	17.60	17.20
OMC (%)	20.00	21.00	18.00	16.00
CBR % (after 7 days moist cured and 4 days soaked)	0.3	4.5	9.3	12.5

2.6 Effect of RBI 81 on Fatigue Life of BC soil

To bring out the effect of stabilizer on the performance of stabilized soils when subjected to repeated loads, experiments are conducted after 7 days and 28 days of curing with a frequency of 1 Hz. Loads corresponding to 1/3rd and half of UCS strength for 2% stabilizer are taken and applied with different percentage of stabilizer. The results of the test are shown in Table 6. A comparative study between original and stabilized soils indicates that the stabilization is effective in improving the fatigue or endurance life of soil samples. Repeated loads corresponding to 1/3rd and half of UCS strength for 2% stabilizer were applied on both 7 and 28 days moist cured specimens. The fatigue life of the stabilized soil rapidly increases for 1/3rd and half load as the stabilizer content increases. The fatigue life of BC soil increases with increase in curing period as shown in Table 6.

Table 6: Fatigue Life test results for untreated and treated soils.

Curing period	Applied load (Kg)	Fatigue life (number of cycles)			
		0% stabilizer	2% stabilizer	4% stabilizer	6% stabilizer
7 days	23	3	1811	3628	4172
	34	2	1126	2277	2987
28 days	31	5	2931	5719	8005
	47	3	1318	2193	3860

2.7 Chemical composition of soils

Addition of stabilizer results in the formation of various chemicals which binds the soil particles together creating crystalline matrix. This formation is evident from the chemical analysis of the treated and untreated soils, results of which are given in Table 7.

Table 7: Chemical composition of treated and untreated soils.

Property	Black Cotton Soil		RBI % by Mass
	Untreated	Treated	
Ca (CaO)	2.93	8.06	52-56
Si (SiO ₂)	61.68	58.31	15-19

S (SO ₄)	0.002	0.59	9-11
Al (Al ₂ O ₃)	14.37	16.71	5-7
Fe (Fe ₂ O ₃)	6.84	8.49	0-2
Mg (MgO)	2.17	1.89	0-1
Others	12.01	10.38	0-8

4. Conclusions

The conclusions that can be drawn from the results can be summarized as follows:

- BC soil showed appreciable improvement in strength with the stabilizer under unsoaked condition.
- From the results of CBR test, it is evident that BC soil treated with 6% stabilizer offers good improvement.
- The most important finding of this work is with regard to fatigue life of treated soils. It shows high fatigue life at 1/3rd corresponding UCS strength values, both at 7 and 28 days of curing. Best results are obtained with 6% stabilizer at 7 and 28 days of curing.
- Evidence for stabilization can be seen from change in chemical composition of soils when treated with the stabilizer. Percentages of Calcium Oxide, Alumina and sulphates, which are important byproducts, are increased on stabilization.

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