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Studies on Black Cotton Soil Treated with Traditional and Non-Traditional Stabilizers

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ABSTRACT: The increase in construction activity around the world creates lot of pressure on present land space. The need for new space often leads to the needs for improving existing spaces, which are otherwise said unsuitable for adopting conventional foundations. One of the fundamental subgrade parameter used is modulus of subgrade reaction i.e K-value. This K-value is a proportionality constant that defines the degree to which the subgrade layer will deform. This report consists of laboratory evaluation of stabilized black cotton soil. Black cotton soil is treated with traditional stabilizers such as Fly ash and non-traditional stabilizer such as RBI-grade81 stabilizer. Black cotton soil is treated with varying stabilizer dosages. Soil was sieved through 425 micron size sieve and cylindrical specimens of 38mm diameter and 76mm height are prepared by addition of stabilizers and cured for 0, 3, 7, 14 and 28 days curing periods and UCS test is conducted. Also 4 days soaked CBR test is conducted with varying stabilizer dosages to check variation in strength parameter of treated black cotton soil. Black cotton soil is treated with stabilizer and compacted to a thickness of 100 mm and Plate Load test is conducted on stabilized and non-stabilized black cotton soil in laboratory in a model box.

KEYWORDS: Black cotton soil, Fly ash, RBI Grade-81, K-value, CBR, UCS, Plate Load test.

I. INTRODUCTION

In developing countries like India the biggest challenge is to provide a complete network of roads in the limited finances available. Therefore there is a need to go for suitable method of low cost road construction, to meet the growing needs of road traffic, thus apart from affecting economy in the initial construction cost of lower layers of the pavement such as sub-base and base course it should be possible to upgrade the low cost roads to higher specification at a later stage with minimal wastage, utilizing the principle of pavement construction in stages. There is no reliable correlation between the three measures of soil properties-modulus of subgrade reaction, soil bearing capacity and soil compressibility, because they are measurements of different characteristics of a soil. The k -value used for slab design reflects the response of the subgrade under temporary (elastic) conditions and small deflections, usually 1.25 mm or less. In this study traditional stabiliser used is Fly ash, Fly ash is one of the largest industrial by-product. It is generated in vast quantities as a by-product of burning coal at electric power plants. Fly ash by itself has little cementitious value but in the presence of moisture it reacts chemically and forms cementitious compounds and results to the improvement of strength and compressibility characteristics of soils. For the present study, fly ash is used from Muddanur, Karnataka. This is class C fly ash, which is suitable for improving soil properties. Another stabiliser which is a non-traditional stabiliser is RBI Grade-81. Alchemist Touchnology Ltd. has focused on the rehabilitation and the new construction of asphalted roads or un-asphalted roads. It is almost unimaginable that an inorganic natural material, once applied to any type of soil, from sand (desert and beach) to active clay, will modify the in-situ soil through a natural mechanism, will render it impermeable, and harden it to the point that it will perform as a wearing course. RBI Grade-81 is a unique and innovative product that was developed for the stabilization of wide spectrum of soils in an efficient, least-cost manner. It is an environment friendly, inorganic, hydration activated powder-based stabilizer that reacts with soil particles to create layers that are interconnected through a complex inter-particle framework. RBI-81 is a unique and highly effective natural inorganic soil stabilizer for Infrastructure development and repair. From rural roadways to runways, RBI Grade-81 provides complete and holistic solutions that are economical, eco-friendly. RBI Grade-81 permits the

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use of a single stabilization product in a wide variety of applications serving very diverse needs, from haul roads and foundation layers in primary roads to bicycle and wheelchair paths, parking lots and more.

II. RELATED WORK

- To evaluate physical properties of Black cotton soil.
- To study variation in consistency limits and strength gain of black cotton soil and black cotton soil treated with fly ash and RBI Grade-81 stabilizer.
- To study variation in K-value and E-value by conducting plate load test in a model box on black cotton soil and black cotton soil treated with fly ash and RBI Grade-81 stabilizer.

III. EXPERIMENTAL RESULTS

TABLE -1: PHYSICAL PROPERTIES OF BLACK COTTON SOIL

Colour	Black	
Specific Gravity	2.56	
Grain size distribution :		
Gravel, %	2.00	
Sand, %	38.20	
Silt and Clay, %	59.80	
Atterberg limits:		
Liquid limit,	45.7	
Plastic limit,	22.14	
Plasticity index,	23.56	
Soil Classification	IS Soil classification	CL
	HRB Classification	A-7(12)
Compaction characteristics:		
Maximum dry density (g/cc)	1.67	
Optimum moisture content, %	20.08	
Soaked CBR, %	3.73	
Un Confined Compressive strength, Kg/cm ²	0.882	

In table 1, Black cotton soil is tested for physical properties and results obtained are tabulated as above. It can be observed these are the details for untreated black cotton soil. Later in the study conducted, black cotton soil is treated with stabilizers and change in engineering properties is observed.

Table -2: Physical Properties of Fly Ash

Properties	Fly Ash
Liquid Limit, %	47%
Plastic Limit, %	NP
Specific gravity	2.08
Maximum Dry Density, g/cc	1.37
Optimum Moisture Content, %	28.24
Percent passing 75 μ sieve, %	39.38

In table 2, Flyash obtained from Muddanur district, Karnataka is tested for Liquid limit, plastic limit, specific gravity, compaction parameters and fineness by percent passing 75 micron sieve. These tests provide information on further variation in black cotton soil physical properties, when treated with flyash.

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Table-3: Black Cotton soil treated with varying percentages of Fly ash

BC Soil+ Flyash	LL	PL	PI	MDD (g/cc)	OMC (%)
0%	45.70	22.14	23.56	1.67	20.08
10%	43.7	21.12	22.58	1.737	17.87
20%	42	23.46	18.54	1.796	17.43
30%	33	24.98	8.02	1.765	17.08

In the table 3, black cotton soil is treated with flyash with increasing percentages of flyash content. In a total mix of soil and flyash, proportion of soil was replaced by flyash and tests are conducted.

Table-4: Black Cotton soil treated with varying percentages of Fly ash

BC Soil+ Flyash	Soaked CBR, %	UCS in Kg/cm ² Curing period in days				
		0 day	3day	7day	14day	28day
0%	3.73	0.882	0.882	0.882	0.882	0.882
10%	10.71	0.752	0.986	1.094	2.155	2.987
20%	5.57	0.856	1.056	1.895	2.789	3.456
30%	5.14	0.773	1.016	1.136	2.214	3.154

In table 4, results are tabulated for black cotton soil treated with flyash. Soaked CBR test and Unconfined compression test are conducted. Soaking of CBR sample is done for 4 days and Unconfined compression test curing periods are varied as 0 days, 3 days, 7 days, 14 days and 28 days.

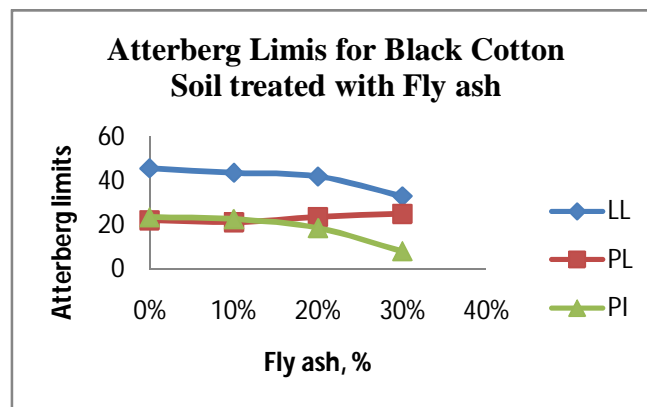


Chart-1: Graph showing variation in Atterberg limits of Black Cotton soil treated with Fly ash In chart1, black cotton soil when it is treated with flyash, variation in atterberg limits viz liquid limit, plastic limit and plasticity index is observed.

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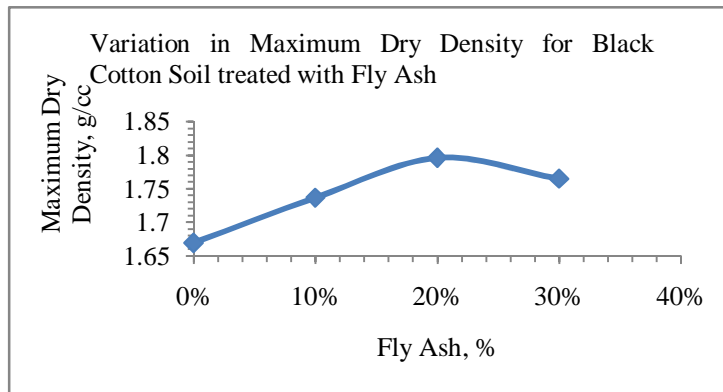


Chart-2: Graph showing variation in MDD of Black Cotton soil treated with Fly ash

In chart2, black cotton soil when it is treated with flyash, variation in maximum dry density is observed. Highest dry density is obtained when 20 % of flyash is used with black cotton soil, tested by light compaction test method.

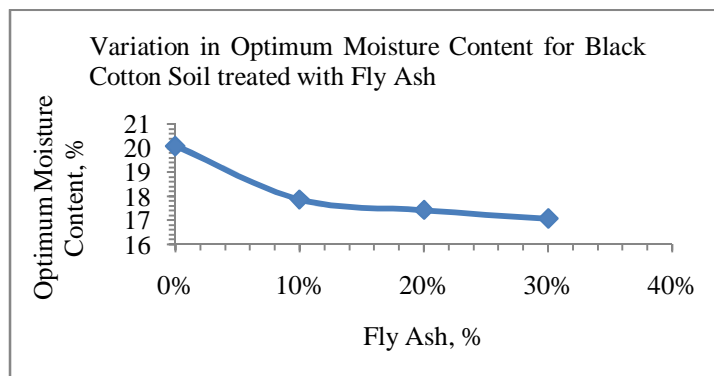


Chart-3: Graph showing variation in OMC of Black Cotton soil treated with Fly ash

In chart3, black cotton soil when it is treated with flyash, variation in optimum moisture content is observed. Optimum moisture obtained from 20 % flyash treated with black cotton soil is used for further test studies.

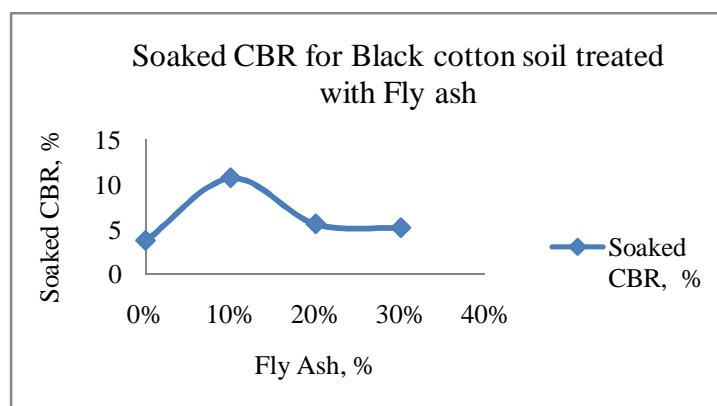


Chart-4: Graph showing variation in Soaked CBR of Black Cotton soil treated with Fly ash

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In chart4, black cotton soil when it is treated with flyash, variation in soaked CBR is observed. Highest soaked CBR is obtained when 10 % of flyash is treated with black cotton soil.

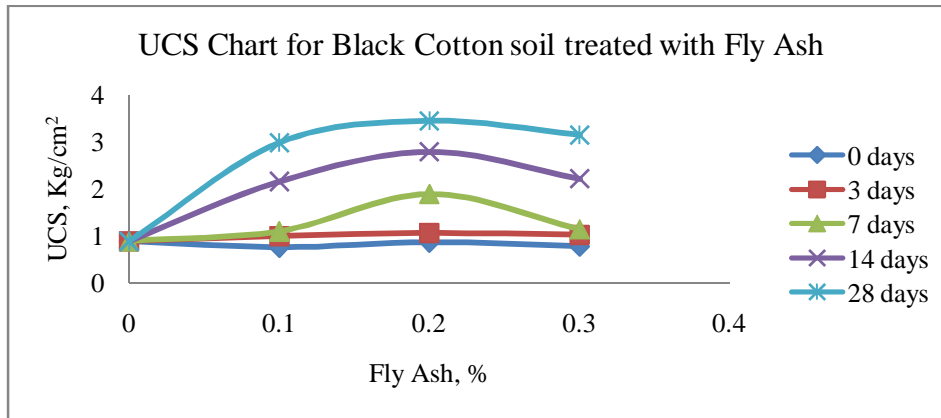


Chart-5: Graph showing variation in Un-confined compressive strength of Black Cotton soil treated with Fly ash In chart5, black cotton soil when it is treated with flyash, variation in unconfined compression test with different curing periods in days is observed. unconfined compression strength is seen to be increasing with increase in curing periods.

Table-5: Physical properties of RBI Grade-81

Property	Results
Odour	Odourless
pH	12.5
Specific Gravity	2.5
Bulk Density	700 Kg/m ³

In table 5, RBI Grade-1 obtained from alchemist touchnology is tested. Specific gravity test and other various test provide information on further variation in black cotton soil physical properties.

Table-6: Black Cotton soil treated with varying percentages of RBI Grade-81

BCSoil+RBI Grade-81, %	LL	PL	PI	MDD, g/cc	OMC, %
0	45.70	22.14	23.56	1.67	20.08
2	44.60	23.90	20.44	1.74	21.09
4	42.74	24.75	17.90	1.76	22.00
6	39.40	26.49	12.61	1.76	22.50
8	38.90	26.66	11.02	1.77	23.46

In the table 6, black cotton soil is treated with RBI Grade-81 with increasing percentages of RBI Grade-81 content. In a total mix of soil and RBI Grade-81, proportion of soil was replaced by RBI Grade-81 and tests are conducted.

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Table-7: Black Cotton soil treated with varying percentages of RBI Grade-81

BC Soil+ RBI Grade-81, %	Soaked CBR, %	UCS in Kg/cm ² Curing period in days				
		0day	3day	7day	14day	28day
0	3.73	0.882	0.882	0.882	0.882	0.882
2	6.07	1.400	2.810	3.200	3.870	4.430
4	14.09	1.810	4.880	5.970	6.990	9.170
6	27.47	1.940	5.990	7.860	9.240	12.11
8	41.90	2.350	9.070	13.50	15.68	17.22

In table 7, results are tabulated for black cotton soil treated with RBI Grade-81. Soaked CBR test and Unconfined compression test are conducted. Soaking of CBR sample is done for 4 days and Unconfined compression test curing periods are varied as 0 days, 3 days, 7 days, 14 days and 28 days.

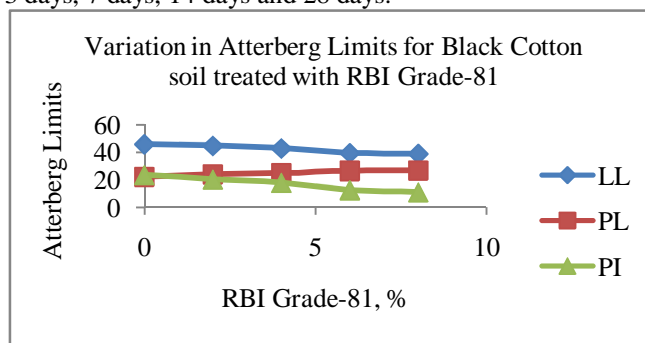


Chart-6: Graph showing variation in Atterberg limits of Black Cotton soil treated with Fly ash

In chart 6, black cotton soil when it is treated with RBI Grade-81, variation in atterberg limits viz liquid limit, plastic limit and plasticity index is observed.

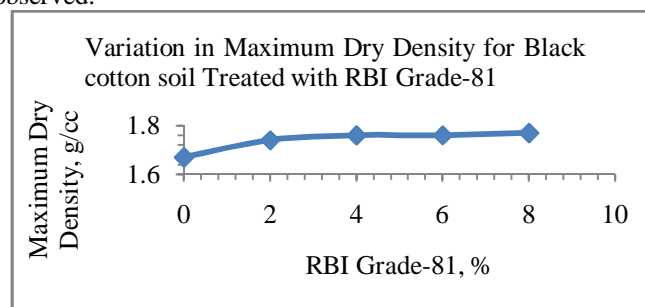


Chart-7: Graph showing variation in MDD of Black Cotton soil treated with RBI Grade-81

In chart 7, black cotton soil when it is treated with RBI Grade-81, variation in maximum dry density is observed. Highest dry density is obtained when 8 % of RBI Grade-81 is used with black cotton soil, tested by light compaction test method.

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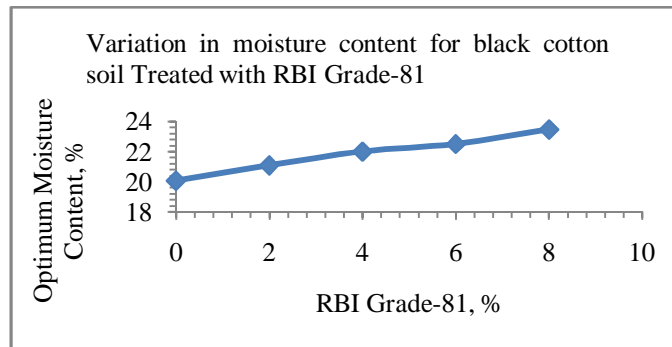


Chart-8: Graph showing variation in OMC of Black Cotton soil treated with RBI Grade-81

In chart 8, black cotton soil when it is treated with RBI Grade-81, variation in optimum moisture content is observed. Optimum moisture obtained from 8 % flyash treated with black cotton soil is used for further test studies.

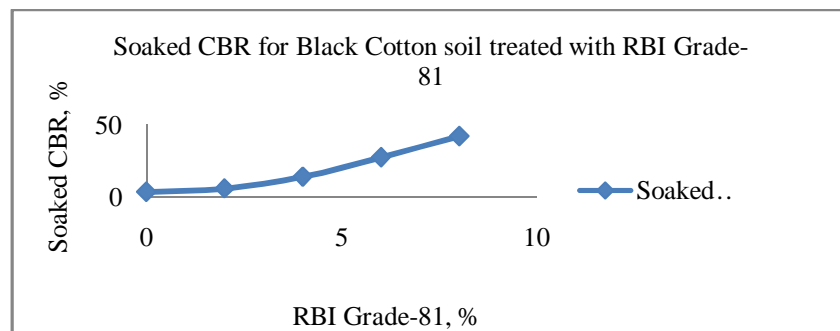


Chart-9: Graph showing variation in Soaked CBR of Black Cotton soil treated with RBI Grade-81

In chart 9, black cotton soil when it is treated with RBI Grade-81, variation in soaked CBR is observed. Highest soaked CBR is obtained when 8 % of RBI Grade-81 is treated with black cotton soil. It is observed that there is a continuous increase in CBR value when black cotton soil is treated with RBI Grade-81.

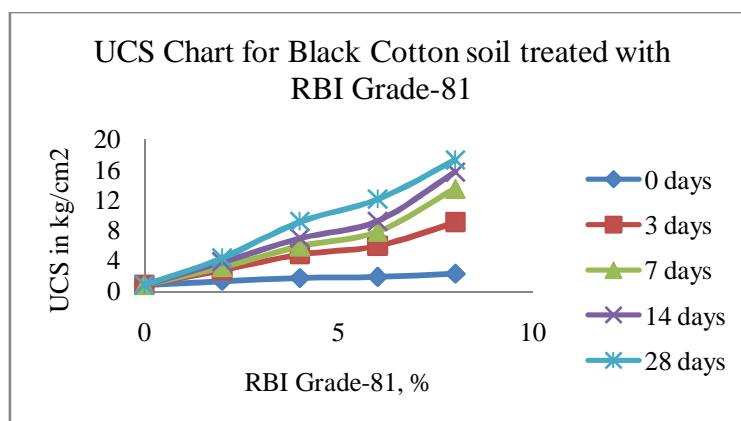


Chart-10: Graph showing variation in Un-confined compressive strength of Black Cotton soil treated with RBI Grade-81

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In chart 10, black cotton soil when it is treated with RBI Grade-81, variation in unconfined compression test with different curing periods in days is observed. unconfined compression strength is seen to be increasing with increase in curing periods.

Table-8: Results of cyclic plate load test for BC soil

Cycles	Total deflection in mm	Plastic deflection in mm	Elastic deflection in mm
1	0.280	0.235	0.045
2	0.835	0.705	0.130
3	1.275	1.035	0.240
4	1.750	1.330	0.420
5	2.275	1.595	0.680
6	2.730	1.850	0.880
7	3.360	2.400	0.960
8	4.125	2.925	1.200
9	4.365	3.125	1.240
10	4.580	3.260	1.320

Table 8, shows values for deflection namely total deflection which will occur when loading is applied on black cotton soil untreated.

Table-9: Results of cyclic plate load test for BC soil treated with Fly Ash

Cycles	Total deflection in mm	Plastic deflection in mm	Elastic deflection in mm
1	0.780	0.650	0.130
2	1.110	0.825	0.285
3	1.620	1.255	0.365
4	2.085	1.550	0.535
5	2.595	1.995	0.600
6	3.200	2.335	0.865
7	3.685	2.665	1.020
8	4.225	3.350	0.875
9	5.235	3.730	1.505
10	5.685	4.200	1.485

Table 9, shows values for deflection namely total deflection which will occur when loading is applied on black cotton soil treated with flyash.

Table-10: Results of cyclic plate load test for BC soil treated with RBI Grade-81

Cycles	Total deflection in mm	Plastic deflection in mm	Elastic deflection in mm
1	0.340	0.330	0.010
2	0.875	0.790	0.085
3	1.340	1.165	0.175
4	1.710	1.41	0.300
5	2.065	1.685	0.380
6	2.500	2.00	0.500
7	2.980	2.405	0.575
8	3.500	2.840	0.660

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9	4.045	3.270	0.775
10	4.600	3.790	0.810

Table 10, shows values for deflection namely total deflection which will occur when loading is applied on black cotton soil treated with RBI Grade-81.

Table-11:List of K-Values and E-values for Black Cotton soil treated with various stabilizers

Particulars	K-Value in Kg/Cm ³ for 30cm dia plate	K-Value in Kg/Cm ³ for 75cm dia plate	E-Value in Kg/cm ²
Black Cotton soil alone	7.840	3.136	138.768
BC soil + RBI Grade81	8.000	3.200	141.600
BC soil + Fly Ash	8.200	3.280	145.140

Table 11, shows values for modulus of subgrade reaction when 30 cm and 75 cm diameter steel plates are used for test. With relation between area of applied load and pressures applied, young's modulus E is calculated. Young's modulus can be used for analysis of different pavement layers.



Fig-1: Model box setup with datum frame, proving ring and dial gauges

Figure 1 shows setup of hydraulic jack, proving ring, datum frame and dial gauges for plate load test. Load is applied using a hydraulic jack, measurement of load is done by proving ring and deflections are measured using dial gauges.

IV. CONCLUSION

Addition of stabilizers such as Fly ash and RBI Grade-81 to the BC soil reduces the liquid limit and plasticity index of soil. In combination, the admixtures are beneficial for lower plasticity and high silt content soils. When Fly ash and RBI Grade-81 are used in the BC soil, it improves the unconfined compressive strength with the increases in the content of stabilizers. Even though the cost of RBI Grade-81 stabilizer is more when compared to other conventional stabilizers such as Fly ash it gives more strength to the pavement thereby decreasing pavement thickness. Thickness required for pavement with stabilized soil subgrade is much lesser than un-stabilized soil subgrade.

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