International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 02 | Feb 2020 www.irjet.net p-ISSN: 2395-0072

Experimental investigation and stabilization of Black Cotton Soil using Micro Silica and Renolith

Mr. Nagarjun Gowda B. S.[1], Mrs. Shilpa M.S[2], Ms. Nidhi.K[3]

[1]*Assistant Professor, Department of CTM, Dayananda Sagar College of Engineering, Karnataka, India*
[2]*Assistant Professor, Department of CTM, Dayananda Sagar College of Engineering, Karnataka, India*
[3]*Student, Department of CTM, Dayananda Sagar College of Engineering, Karnataka, India*

Abstract - *Due to rapid growth of urbanization and industrialization, minimization of industrial waste is serious problem in present days. To encounter this innovation and nontraditional research on waste utilization is gaining now a day. Soil improvement using the waste material like slag, Rice husk ash, silica fume etc. in geotechnical engineering has been recommended from environmental point of view. The main objective of this study is to evaluate the feasibility of using silica fume as soil stabilization material. In this paper the effect of silica fume on engineering characteristics of expansive clay like black cotton soil has been presented. A series of laboratory experimental has been conducted on black cotton soil blended with silica fume content from 5%, 10%, 15% and 20% by weight of dry soil. The experimental result showed a significant increase in California bearing ratio and unconfined compressive strength. Another stabilization material called Renolith is also used in this study. Renolith is a polymer based chemical solution composed of formulated Nano emulsion based styrene acrylic. It is available in a liquid form. The influence of Renolith and micro silica stabilized black cotton soil was investigated to find out the improvement in the compaction characteristics, mechanical strength and shear capacity (i.e., OMC, MDD, CBR and UCC). The obtained result shown an array of improvement over percentage of micro silica kept constant (i.e., 15%) and Renolith varied (i.e. 5%, 7.5%, 10% and 12.5%). There was maximum increase in CBR and UCC values.*

***Key Words*: Soil Stabilization, Black Cotton Soil, Micro silica, Renolith**

1. INTRODUCTION

Sub grade soil is an integral part of the road pavement from beneath. The sub grade soil and its properties are important in the design of pavement structures. The main function of the sub grade is to give support to the pavement. And for this, the sub grade should possess sufficient stability under adverse climate and loading condition. Soil stabilization is a process which improves the physical properties of soil, such as increasing the shear strength, bearing capacity and the resistance to erosion, dust formation, or frost heaving. The stabilization methods used are divided into mechanical, chemical and electro chemical methods.

Mechanical methods are those in which compaction or bulk density is increased by dynamic or vibro compaction. Electro chemical methods of stabilization involve the reduction of water content by electro osmosis. Chemical stabilization is one of the effective stabilization techniques.

1.1 Black Cotton Soil

Black cotton soil is the Indian name given t expansive soil. Expansive soils are those whose volume changes takes place while it comes in contact with water. It expands during rainy season due to intake of water and shrinks during summer season. Expansive soils owe their characteristics to the presence of swelling clay minerals. The main properties of expansive soil are swelling properties like free swell index, swell potential and swelling pressure which directly affect the bearing capacity and strength of foundation lying on such soil. Typical behavior of swell and shrink of expansive soil causes problems like cracks in foundations. Hence it is necessary to improve the properties of such soils to avoid damage of structure.

1.2 Micro Silica and Renolith

Silica fume, also known as micro silica, is an amorphous (non-crystalline) polymorph of silicon dioxide, silica. It is an ultrafine powder collected as a by-product of the silicon and ferrosilicon alloy production and consists of spherical particles with an average particle diameter of 150 nm. The main field of application is as pozzolanic material for high performance concrete.

Table -1: Properties of Micro Silica

Properties	Values
Specific Gravity	2.20
Silica (SiO_2)	90%
Bulk Density	500-700 Kg/m^3
Specific Surface Area	2000 m^2/kg

Renolith is a polymer based chemical solution and it is formed by formulated Nano emulsion based on styrene acrylic. It is available in liquid form. Renolith when thoroughly mixed and stabilized with a soil or road pavement materials, cement and water produces an exothermic reaction and forms a polymer which when compacted provides a very dense layer. Renolith was found to be non-toxic to the user as well as to the environment.

Table -2: Specification of Renolith

Properties	Description
Physical Form	Liquid
Chemical Composition	Formulated Nano emulsion based styrene acrylic
Solids %	7±1
p^H	7-9
Viscosity	<1000
Specific gravity	1.05-1.1

In order to explore the effectiveness of the combination of Renolith Micro Silica as a stabilizer for Black Cotton Soil, the following objectives were planned:

- To determine the change in geotechnical properties (if any), upon addition of different percentage of additive combination (i.e. Renolith and Micro silica).
- To check the economic feasibility of Renolith with the Black Cotton Soil along with the Micro silica.

2. METHODOLOGY

Materials used: Black cotton soil, Micro silica and Renolith.

The following tests were conducted on black cotton soil:

- Specific gravity test
- Atterberg Limits: Liquid Limit, Plastic Limit, Shrinkage Limit
- Compaction test
- California Bearing Ratio test (CBR test)
- Unconfined Compression Strength test (UCC TEST)

Initially above tests were conducted on black cotton soil to find out its properties. Then soil was partially replaced by mineral admixtures like Micro silica and its results was compared with that of conventional black cotton soil. Then as part of further study, a chemical called Renolith was also added to the partially replaced black cotton soil. Finally, from the results obtained from the each test was compared which conclude the percentage replacement of each admixture.

The tests carried out on stabilized sample in which the Micro silica content varied in percentage of 5%, 10%, 15% and 20% of the dry weight of soil sample. Then Renolith was added in varying percentages of 5%, 7.5%, 10% and 12.5% respectively.

1. TESTS ON BLACK COTTON SOIL

SPECIFIC GRAVITY TEST

Table 3 Specific gravity of untreated Black Cotton Soil

Sl no	Observation	1	2	3
1	Weight of Pycnometer (W_1)g	630	630	630
2	Weight of Pycnometer+ Dry Soil (W_2)g	1025	1030	1025
3	Weight of Pycnometer+ Dry Soil+ Water (W_3)g	1718	1736	1724
4	Weight of Pycnometer+ Water (W_3)g	1470	1470	1470
5	$G=\frac{(W_2-W_1)}{(W_2-W_3)-(W_3-W_4)}$	2.68	2.90	2.80

ATTERBERG LIMIT TESTS:

Table 4 Liquid limit of untreated Black Cotton Soil

Trial No.	1	2	3	4
Empty Weight of Container (g)	42.30	39.34	39.00	29.30
Weight of container + wet soil (g)	45.30	42.50	43.00	32.70
Weight of container + dry soil (g)	44.15	41.25	41.50	31.50
Water Content (%)	62.16	65.44	68.18	70
No. of Blows	48	36	20	18

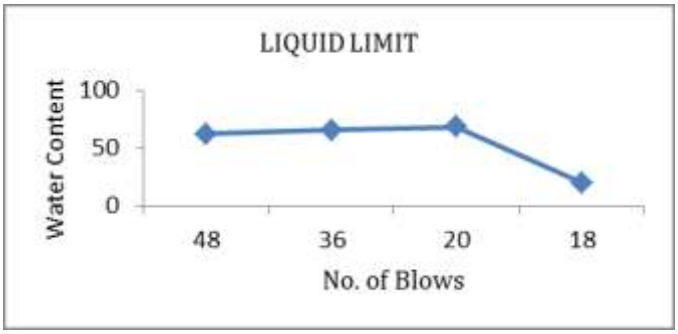


Chart 1 Flow Curve for Black Cotton Soil

Table 4 Plastic limit of untreated Black Cotton Soil

Sl no	Observation	1	2	3
1	Container Number	101	103	140
2	Weight of Container+ lid (W_1)g	25	33	40
3	Weight of Container+ lid+ Wet Soil (W_2)g	34	42.5	53
4	Weight of Container+ lid+ Dry Soil(W_3)g	31	39.5	49
5	Weight of Soil (W_3-W_2)g	3	3	4
6	Weight of Water	6	6.5	9

COMPACTION TEST:

Table 5 Compaction of untreated Black Cotton Soil

Observation	1	2	3	4	5	6	7
Water to be added (%)	10	12	14	16	18	20	22

Weight of water to be added, g	250	300	350	400	450	500	550
Weight of mould + compacted soil, g	3480	3680	3830	3920	4100	3850	3630
Weight of compacted soil, g	1350	1550	1700	1790	1970	1720	1500
Wet density (g/cc)	1.43	1.64	1.80	1.89	2.08	1.82	1.58
Dry density (g/cc)	1.30	1.46	1.59	1.63	1.77	1.53	1.30

Table 6 Moisture content of untreated Black Cotton Soil

Observation	1	2	3	4	5	6	7
Weight of empty container with lid, W_1 g	39	36	35	37	40	35	39
Weight of container + wet soil, W_2 g	91	64	80	100	67	65	73
Weight of container + dry soil, W_3 g	86.5	61	75	92	63	60.5	67
Moisture Content, w%	9.47	12	13.25	15.27	17.4	18.64	21.4

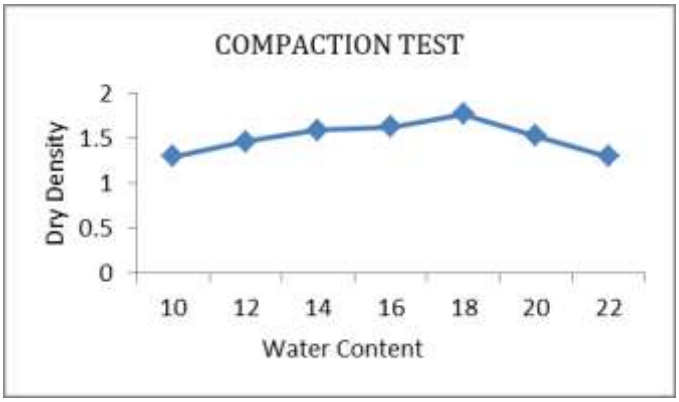


Chart 2 Compaction Curve for Black Cotton Soil

UNCONFINED COMPRESSION TEST (UCC):

Length of the cylindrical specimen = 7.5cm
Proving ring reading: 22.2 div
Dial gauge reading: 450*0.01 = 4.5mm
Compressive load, $q_u = \frac{\text{Load}}{\text{Corrected area}}$
Corrected area $(C_A) = \frac{A_0}{1-e}$
A_0 = 11.34 cm^2
$C_A = \frac{11.34}{(1-0.06)}$ = 12.06 cm^2
$q_u = \frac{0.046}{12.06*10-4}$ = 38.16 kN/m^2

CALIFORNIA BEARING TEST (CBR):

Table 7 CBR of untreated Black Cotton Soil

Penetration	Division	Load(kN)	Load(kg)
0	0	0	0
0.5	2.0	0.092	9.30
1.0	3.0	0.138	14.06
1.5	4.5	0.207	21.10
2.0	6.0	0.276	28.13
2.5	7.5	0.345	35.16
3.0	8.0	0.368	37.51
3.5	8.5	0.391	39.85
4.0	9.5	0.437	44.54
5.0	11.0	0.506	51.58
7.5	13.2	0.621	63.30
10.0	17.0	0.782	79.71
12.5	20.0	0.820	83.58

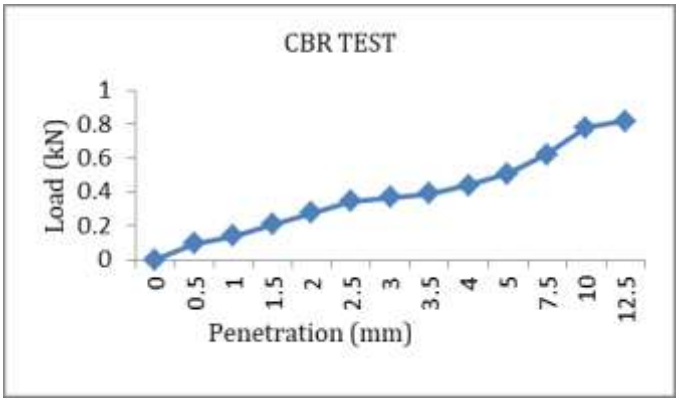


Chart 3 CBR Curve for Black Cotton Soil

PROPERTIES OF BLACK COTTON SOIL:

Table 8 CBR of untreated Black Cotton Soil

Sl No.	Properties	Result	Relevant IS Code
1	Specific Gravity	2.79	IS 2720 Part 3
2	Liquid Limit	67.4%	IS 2720 Part 5
3	Flow Index	20%	IS 2720 Part 6
4	Plastic Limit	46.86%	IS 2720 Part 5
5	Plasticity Index	19.64%	IS 2720 Part 5
6	Optimum Moisture Content	18%	IS 2720 Part 8
7	Maximum Dry Density	15.9kN/m^3	IS 2720 Part 8
8	California Bearing Ratio	2.56%	IS 2720 Part 16
9	Unconfined Compressive Strength	38.16kN/m^2	IS 2720 Part 10

2. TESTS ON MICRO SILICA

STANDARD PROCTOR COMPACTION TEST:

Table 9 Variation of OMC and MDD of Black Cotton Soil with varying percentage of Micro silica

Percentage of Micro Silica	OMC (%)	MDD (kN/m³)
0	18	15.90
5	10	15.12
10	10	14.50
15	8	15.10
20	6	14.73

UNCONFINED COMPRESSION TEST:

Table 10 Unconfined compressive strength of black cotton soil at varying percentage of Micro Silica

Percentage of Micro Silica	UCS in kN/m²
0	38.14
5	50.33
10	85.20
15	105.60
20	120.20

CALIFORNIA BEARING RATIO TEST:

Table 11 Variation of CBR values with different percentage of Micro silica

% of Micro Silica	CBR %
0	2.81
5	3.76
10	4.12
15	9.50
20	14.50

3. TESTS ON RENOLITH ALONG WITH MICRO SILICA

STANDARD PROCTOR COMPACTION TEST:

Table 12 Variation of OMC and MDD values when black cotton soil treated with 15% Micro Silica and different percentage of Renolith

% of Renolith	OMC (%)	MDD (%)
5	14	14.82
7.5	12	15.59
10	12	16.48
12.5	10	16.43

CALIFORNIA BEARING RATIO TEST (CBR):

Table 13 Variation of CBR values when black cotton soil treated with 15% Micro Silica and different percentage of Renolith

% of Renolith	CBR %
5	4.40
7.5	6.48
10	9.24
12.5	12.50

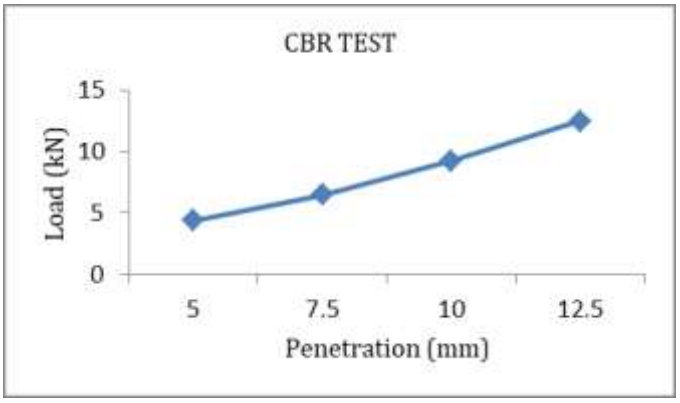


Chart 4 CBR Curve for Renolith along with micro silica

UNCONFINED COMPRESSION TEST (UCC):

Table 14 Variation of UCC values when black cotton soil treated with 15% Micro silica and different percentage of Renolith

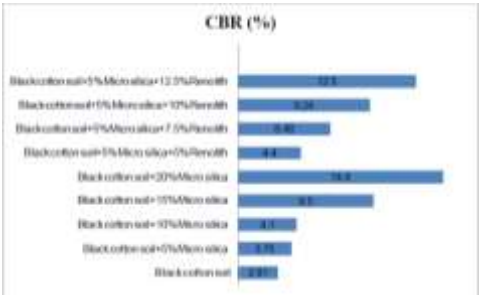
% of Renolith	UCC (kN/m²)
5	158.40
7.5	165.83
10	219.52
12.5	237.70

3. CONCLUSIONS

Black cotton soil is stabilized by Micro silica and Renolith. As the black cotton soil is replaced by various percentages of Micro silica, we observed that CBR and UCC value has increased with increase in the percentage of Micro silica and OMC value deceases and MDD value increases with increase in the percentage of replacement of Micro silica. As the percentage of Renolith varies (5%, 7.5%, 10% and 12.5%) with optimum dosage Micro silica (15%) the OMC value decreases and MDD increases. Also, the CBR and UCC value also increases. The variations in the strength of the Black Cotton Soil is due to following factors:

- Reduction in the cohesion of black cotton soil due to the addition of coarser materials.
- Increase in the strength of the soil due to cementation of pozzolanic compounds produced.

- Occupation of Micro silica particles by finer soil particles.



As the percentage of additive (Micro silica 5,10,15,20%) increases the CBR and UCC value increases, because when water is mixed with soil the voids will form so the micro silica fill the voids. Hence, the strength of the soil increases.

- The stabilized UCS value shows a 75.92% increase when Micro silica proportion is 15% and Renolith proportion is 5%.
- The stabilized UCS value shows a 77.00% increase when Micro silica proportion is 15% and Renolith proportion is 7.5%.
- The stabilized UCS value shows a 82.62% increase when Micro silica proportion is 15% and Renolith proportion is 10.0%.
- The stabilized UCS value shows a 84% increase when Micro silica proportion is 15% and Renolith proportion is 12.5%.

REFERENCES

[1] Azzawi et al (2012) International Journal on "Effect of Silica Fume on Engineering Properties of Black Cotton Soil", volume 3, issue 7.
[2] Shivangi Bharadwaj et Al(2016) International Journal on "Impact of Micro Silica Fume on Engineering Properties of Expansive Soil", volume 2, issue 12.
[3] Owolabi T.A and Aderinola O.S.: (March 17th, 2014) performed study on "An assessment of Renolith on cement-stabilized poor lateritic soils". Sci-Afric Journal of Scientific Issues, Research and Essays Vol. 2 (5), Pp. 222-237, May, 2014. (ISSN 2311-6188).
[4] S. Jayalekshmi and Methku Anvesh Reddy: (December 10th, 2012) performed study on "Studies on Polymer Based Chemical Treated Clay Soil". International Journal of Engineering Research & Technology (IJERT) Vol. 1 Issue 10, December- 2012 ISSN: 2278- 0181.
[5] S.W.Thakare, Priti Chauhan Jan 2016 "Stabilization of Expansive Soil with Micro Silica, Lime and Fly Ash for Pavement" Volume No.5, Issue Special 1, 8 & 9 Jan 2016.