Comparative Study of Stabilization of Black Cotton Soil and Clay Soil using Bagasse Ash and Tyre Cord

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Abstract-The soil stabilization constitutes an increasingly important issue in the present civil engineering world. So the modern soil stabilization techniques are necessary to assure adequate stability, especially for weaker or wetter soils. The selected material should be both durability and for economically low cost. In this research the two expansive soils of black cotton and clay soil are stabilized by using bagasse ash and tyre cord material and compared their result. The tyre cord was varied from 0.5% to 4% , the bagasse ash was varied from 1% to 6% and the both materials was varied from 1% to 8% for each soils and unconfined compressive test was carried. The test result shows the optimum percentage of tyre cord 3% give the shear strength of 0.161 kg/cm2 for black cotton soil and 0.1985 kg/cm2 clay soil, the optimum percentage of bagasse ash 4% give the shear strength of 0.149 kg/cm2 for black cotton soil and 0.463 kg/cm2 for clay soil. The optimum percentage of combination of both materials 6% give the shear strength of 0.463 kg/cm2 for clay soil and 0.386 kg/cm2 for black cotton soil. The result shows the clay soil was more stable and high shear strength compared to the black cotton soil.

Key Words: Soil Stabilization, Unconfined Compressive Strength, Bagasse Ash, Tyre Cord

INTRODUCTION

To study the physical and engineering properties of untreated soil with bagasse ash and tyre cord material.

To evaluate the changes in strength characteristics of untreated and treated soil specimens by Compaction test, Unconfined Compressive Strength etc.

Need and Scope:

Improve the mechanical properties of Black Cotton Soil and Clay Soil.

Improve structural stability.

By improving the shear strength of soil by using bagasse ash and tyre cord.

Improve the bearing capacity of soil by introducing the bagasse ash and tyre cord.

Soil Stabilization:

Soil stabilization is the alteration of one or more soil properties, by mechanical or chemical means, to create an improved soil material possessing the desired engineering properties. The process may include blending of soils to achieve a desired gradation or mixing of commercially available additives that may alter the gradation, texture or plasticity, or act as a binder for cementation of the soil

Types of Soil Stabilization:

The two frequently used methods of stabilizing soils are stabilization by compaction or stabilization by chemical additives.

Mechanical Stabilization:

Mechanical stabilization can be defined as a process of improving the stability and shear strength characteristics of the soil without altering the chemical properties of the soil. The main methods of mechanical stabilization can be categorized in to compaction, mixing or blending of two or more gradations, applying geo-reinforcement and mechanical remediation.

Chemical Stabilization

Soil stabilization using chemical admixtures is the oldest and most widespread method of ground improvement. Chemical stabilization is mixing of soil with one or a combination of admixtures of powder, slurry or liquid to improve or control its stability, strength, swelling, permeability and durability. Soil improvement by means of chemical stabilization can be grouped into three chemical reactions; cation exchange, flocculation-agglomeration pozzolanic reactions.

Uses of Stabilization:

Each layer must resist shearing, avoid excessive deflections that cause fatigue cracking within the layer or in overlying layers, and prevent excessive permanent deformation. As the quality of a soil layer is increase, the ability of that layer to distribute the load over a greater area generally increase so that a reduction in the required thickness of the soil and surface layers may be permitted.

Bagasse Ash:

Bagasse is the fibrous residue obtained from sugarcane after the extraction of sugar juice at sugar cane mills. Bagasse ash is the residue obtained from the incineration of bagasse. Previously, bagasse was burnt as a means of solid waste disposal. However, as the cost of fuel oil, natural gas and electricity has increased, bagasse has come to be regarded as a fuel rather than refuse in the sugar mills. The fibrous residue used for this purpose leaves behind about 8-10% ash, known as bagasse ash.

Bagasse Ash as a Soil Stabilizing Material

These days sustainability plays the major role in every aspect of human activities. Many technologies came to end because they were not in harmony with the idea of sustainable development. Sustainability is concerned about the world we will be leaving behind for future generations. It focuses on the social, environmental and economic issues of human activities. Therefore it requires every activity to be environmental friendly, economical and safe for the social. Bagasse ash contains large amount of silica which is the most important component of Cement replacing materials. It is also found in large amount as a byproduct in sugar factories.

Despite this abundance and silica content, relatively little has been done to examine the potential of this material for soil stabilization.

Fig-1 Bagasse Ash

Colour : black and grey

Specific gravity : 1.8

Tyre Cord:

The fiber is derived from waste material of tire cord factory products. The main constitutive substance of this fiber is nylon 6–6. High resistance against heat, fatigue, impact, and sunlight, and high resilience are some of the valuable characteristics of this fiber, which is usually used in tire and seat belt of vehicles, fishnet, reinforced hoses, and so on. In tire cord company, quality control unit regularly tests samples of productions based on tensile strength, tensile strain at failure point, H-adhesion test, absorption percentage of resorcinol formaldehyde latex (RFL) which is used for adhesion between the interface of fiber and rubber, and hot air thermal shrinkage. The products which do not satisfy particular standards and also, some fibers which become torn in tire production process are discarded as waste products. Usually 10% of nominal production capacity of tire cord factories is waste material.

Fig-2 Tyre Cord

Fibre type : yarned (nylon 6-6)

Length of fibre : 2.5cm

Equivalent diameter : 0.54mm

Specific Gravity Test Objective:

Table 1: Specific Gravity of Black Cotton Soil

S. No	Test Weights	Sample1 (gms)	Sample2 (gms)	Sample3 (gms)
1	Weight of Pycnometer (w1)	670	670	670
2	Weight of Pycnometer and Soil (w2)	1387	1337	1360
3	Weight of Pycnometer ,Soil and Water (w3)	2014	1964	1987
4	Weight of Pycnometer and Water (w4)	1562	1562	1562

Specific Gravity (G) = **2.60**

Table 2: Specific Gravity of Clay Soil

S. No	Test Weights	Sample 1 (gms)	Sample 2 (gms)	Sample 3 (gms)
1	Weight of Pycnometer (w1)	670	670	670
2	Weight of Pycnometer and Soil (w2)	1263	1286	1238
3	Weight of Pycnometer ,Soil and Water (w3)	1940	1963	1914
4	Weight of Pycnometer and Water (w4)	1562	1562	1562

Specific Gravity (G) = **2.75**

Sieve Analysis Test Objective:

Table 3: Sieve Analysis of Black Cotton Soil

Sieve size (μ)	Weight of soil with sieve (gms)	Weight of sieve (gms)	Weight of soil (gms)	Cumulative retained (gms)	Percentage of cumulative retained	Percentage of finess (%)
600	343	343	0	0	0	0
425	412.5	344	68.5	68.5	6.85	93.15
300	680	346	334	402.5	40.25	59.75
150	802	364	438	840.5	84.05	15.95
75	408.5	301	107.5	948	94.8	5.2
Pan	346	312	52	1000	100	0

Finess Modulus = **2.259.**

Table 4: Sieve Analysis of Clay Soil

Sieve size (μ)	Weight of soil with sieve (gms)	Weight of sieve (gms)	Weight of soil (gms)	Cumulative retained (gms)	Percentage of cumulative retained	Percentage of finess (%)
600	340	340	0	0	0	0
425	404	343	61	61	6.1	93.9
300	748	346	402	463	46.3	53.7
150	827	361	466	929	92.9	7.1
75	356	297	59	988	98.8	1.2
Pan	311	308	12	1000	100	0

Finess Modulus = **2.441**

Liquid Limit Test Objective:

To determine the liquid limit of fine soil by using Casagrande Apparatus

Reference:

IS: 2720 (Part 5)-1985 – Method of test for soils (Liquid Limit Determination).

Plastic Limit of Soil Objective:

Table 7: Plastic Limit for Black Cotton Soil

Soil Condition	Sample 1 (gms)	Sample 2 (gms)	Sample 3 (gms)
Wet(w2)	33	30.5	32
Dry(w3)	29	25.5	26.5

Plastic Limit for Black Cotton Soil = **30.78%**

Table 8: Plastic Limit for Clay Soil

Soil Condition	Sample 1 (gms)	Sample 2 (gms)	Sample 3 (gms)
Wet(w2)	34	35	36
Dry(w3)	31.5	28.5	29.5

Plastic Limit for Clay Soil = **29.11%**

Black Cotton Soil

Liquid Limit = 48%

Plastic Limit = 30.78%

Flow Index = 22.23

Plasticity Index = 17.22

Toughness Index = 0.774

Clay Soil

Liquid Limit = 43.33%

Plastic Limit = 29.11%

Flow Index = 37.613

Plasticity Index = 14.22

Toughness Index = 0.378

Standard Proctor Test Objective:

Observations:

Diameter of Mould = 10 cm;

Height of Mould= 12 cm

Volume of Mould = 942.47 cm^3

Weight of mould (w1) = 3859 g

Weight of Soil taken = 3kg

Weight of rammer = 2.6kg

Number of layers = 3 ;

Number of Blows = 25

For Black Cotton Soil, Specific Gravity = 2.6

Table 9 for Compaction test for Black Cotton Soil:

S. No	Water Content (w) %	Weight of Mould + Soil (w2) (grams)	Weight of Soil (W)= (w2 –w1) (grams)	Bulk Density (γ) = W/V (g/cm3)	Dry Density(γ_d) = γ /(1+ w)(g/cc)	(γ_d)100% saturation=(G γ_d /1+wG) (g/cc)
1.	6	5503	1644	1.744	1.645	2.249
2.	8	5584	1725	1.830	1.694	2.152
3.	10	5668	1809	1.919	1.744	2.063
4.	12	5718	1859	1.972	1.760	1.981
5.	14	5780	1921	2.038	1.787	1.906
6.	16	5669	1810	1.920	1.655	1.836
7.	18	5519	1660	1.761	1.492	1.77
8.	20	5469	1610	1.708	1.423	1.71
9.	22	5408	1549	1.643	1.346	1.654

For Clay Soil, Specific Gravity (G) = **2.75**

Table 10 for Compaction test for Clay Soil:

S.No	Water Content (w)(%)	Weight of Mould + Soil (w2) (gms)	Weight of Soil (W)=(w2–w1) (gms)	Bulk Density (γ) = W/V(g/cm3)	Dry Density(γ_d)= γ /(1+ w)(g/cc)	(γ_d)100% saturation= (G γ_d/1+wG) (g/cc)
1.	6	5860	2001	2.123	2.00	2.36
2.	8	5915	2056	2.181	2.018	2.25
3.	10	5960	2101	2.22	2.019	2.15
4.	12	6005	2146	2.276	2.032	2.06
5.	14	6074	2215	2.350	2.061	1.98
6.	16	6145	2286	2.425	2.090	1.909
7.	18	6063	2204	2.338	1.981	1.839
8.	20	6012	2153	2.284	1.903	1.774

Optimum Moisture Content = 16%.

Unconfined Compression Test Purpose:

Observations:

Length of Sample = 7.8 cm

Diameter of Sample = 3.8 cm

Initial area of the sample (Ao) = (π /4) * (3.8)2

= 11.34 cm2

Fig-3 Unconfined Compression

Table-11 for UCS of Black Cotton Soil

Deflection Dial Reading	Proving Ring Reading	ΔL (mm)	Strain e = ΔL/L(%)	Load (P) (kg)	Area = A0 / (1 − e)(cm2)	Stress = (P/A) (kg/cm2)
100	0.4	1	1.28	0.509	11.48	0.044
200	0.6	2	2.5	0.764	11.63	0.065
300	0.8	3	3.8	1.019	11.78	0.086
400	0.9	4	5.1	1.146	11.94	0.095
500	1.0	5	6.4	1.274	12.11	0.105
600	1.2	6	7.6	1.529	12.27	0.124
700	1.4	7	8.9	1.783	12.44	0.143
800	1.6	8	10.2	2.038	12.62	0.161
900	1.8	9	11.5	2.293	12.82	0.178

Unconfined compressive strength (qu) =0.178 kg/cm2

Shear Strength (Cu)= qu/2 = (0.178/2) = 0.089 kg/cm2

Table-12 for UCS of Clay Soil

Deflection Dial Reading	Proving Ring Reading	ΔL (mm)	Strain e=ΔL/L(%)	Load (P)(kg)	Area = A0 / (1 – e)(cm2)	Stress = (P/A) (kg/cm2)
100	0.6	1	1.28	0.764	11.48	0.066
200	1.2	2	2.5	1.529	11.63	0.131
300	1.4	3	3.8	1.783	11.78	0.151
400	1.6	4	5.1	2.038	11.94	0.170
500	1.8	5	6.4	2.293	12.11	0.189
600	2.0	6	7.6	2.548	12.27	0.207

Unconfined compressive strength (qu) = 0.207 kg/cm^2

Shear Strength (Cu) = qu/2 = (0.207/2) = 0.1035 kg/cm^2

Fig-5 Sample placed in UCS apparatus

Fig-6 Samples under Loading in UCS apparatus

Fig-7 Soil Samples after loading in UCS apparatus

Results and Discussion

The bagasse ash and tyre cord material are tested with both the soil in different percentages like bagasse ash is mixed as (1% - 6%) and tyre cord as (0.5% - 4%) then these materials are mixed together in a percentage of (1-1% - 8-8%) with the soil in the Unconfined Compressive Strength Test.

Table 25 Test Results for Black Cotton Soil

S.No	Materials To Be Used	Optimum Percentage (%)	UCS Value (qu) (kg/cm2)	Shear Strength(Cu) (kg/cm2)
1	Bagasse ash	4	0.282	0.141
2	Tyre cord	3	0.397	0.1985
3	Tyre cord and Bagasse ash	6	0.842	0.421

Table 26 Test Results for Clay Soil

S.No	Materials To Be Used	Optimum Percentage (%)	UCS Value (qu) (kg/cm2)	Shear Strength(Cu) (kg/cm2)
1	Bagasse ash	4	0.298	0.149
2	Tyre cord	3	0.322	0.161
3	Tyre cord and Bagasse ash	6	0.772	0.386

Conclusion

From the above tests, using baggase ash and tyre cord as separately, for black cotton soil we get the value of shear strength 0.149 kg/cm^2 at 4% of bagasse ash and 0.161 kg/cm^2 at 3% of tyre Cord, for the black cotton soil then by using baggase ash (6%) and tyre cord (6%) as combined, we get the value of shear strength of 0.386 kg/cm^2 for the black cotton soil. Further increasing percentage of bagasse ash and tyre cord, the shear strength value decreases for black cotton soil. Also for clay soil we get the value of shear strength 0.141kg/cm^2 at 4% of bagasse ash and 0.1985kg/cm^2 at 3% of Tyre Cord, for the clay soil then by using baggase ash (6%) and tyre cord (6%) as combined, we get the value of shear strength of 0.463 kg/cm^2 for the clay soil.

Further increasing percentage of bagasse ash and tyre cord, the shear strength value decreases for clay soil.

From the above the result, the clay soil was more stable and high shear strength compared to the black cotton soil.

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