Stabilization in Expansive Soil using Flyash

Namrata D. Agnihotri[1] Mitul V. Undhad[2] ParitV. Chotaliya[3] Tarun P. Ramnani[4]
[1]Lecturer [2,3,4]Student
[1,2,3,4]Department of Civil Engineering
[1,2,3,4]AITSDS-Rajkot, Gujarat, India

Abstract— Soil stabilization is one of most important for the construction which is widely used in connection with road pavement and foundation construction because it improves the engineering properties of soil such as strength, volume stability and durability. In the present investigation is to evaluate the compaction and unconfined compressive strength of stabilized black cotton soil using fine and coarse fly ash mixtures. The percentage of fine and coarse fly ash mixtures which is used in black cotton soil varied from 5 to 30. In the study concludes that with percentage addition of fine, coarse fly ash improves the strength of stabilized black cotton soil and exhibit relatively well-defined moisture-density relationship. It was found that the peak strength attained by fine fly ash mixture was 25% more when compared to coarse fly ash. The main objective of this study is to investigate the use of waste materials in geotechnical applications and to evaluate the effects of waste polypropylene fibers on shear strength of unsaturated soil by carrying out direct shear tests and unconfined compression tests on two different soil samples. The results obtained are compared for the two samples and inferences are drawn towards the usability and effectiveness of fiber reinforcement as a replacement for deep foundation or raft foundation, as a cost effective approach.

Key words: Soil Stabilization, Fly Ash, Plasticity Waste Material

I. Introduction

Expansive clay soils are extensively distributed worldwide, and are a source of great damage to infrastructure and buildings. In monsoon they imbibe water and swell and in summer they shrink on evaporation of water from there. Because of this alternative swelling and shrinkage, lightly loaded civil engineering structures like residential buildings, pavements and canal linings are severely damaged.

There are three basic types of soil naturally occurring in this area: sand, silt and clay. Clay soils are generally classified as “expansive”. This means that a given amount of clay will tend to expand (increase in volume) as it absorbs water and it will shrink (lessen in volume) as water is drawn away. The effects can be dramatic if expansive soils supporting structures are allowed to become too wet or too dry.

Fig. 1: Cracks in expansive soil when soil is dry due to shrinkage

Map of soil deposits in Gujarat State shows that the majority of Gujarat area having black cottons soil as top layer.

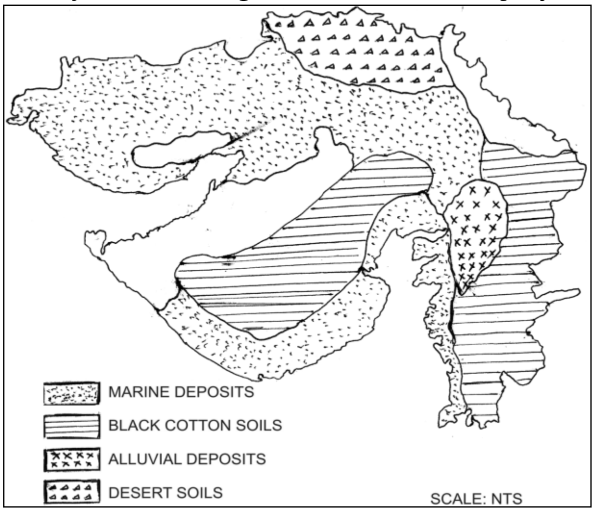


Fig. 2: Map of Soil Deposits in Gujarat State

Property	Range
Field Moisture Content (%)	10 – 35
Field Dry Density (gm/cc)	1.15 - 1.65
Liquid Limit (%)	40 – 75
Plastic Limit (%)	18 – 35
Shrinkage Limit (%)	8 – 20
Free Swell Index	40 – 80
Swelling Pressure (kg/cm2)	0.065 - 0.258

Table 1: Properties of the black cotton soil

II. Scope

Review of Literature..Finding out the basic properties of natural soil on which experiments to be performed. E.g. Core cutter, Grain size analysis compaction test UN confined compressive stress etc.

To conduct the series of twelve experiments based on laboratory test on natural soil with using different percentage of fly ash for Stabilization of expansive soil

III. Need of Study

To evaluate the property, suitability & stability of expansive black cotton soil before and after stabilization by chemical stabilization techniques using fly ash.To investigate the mechanical properties of the soil with respect to mix proportion, such as percentage of stabilizing agent (Fly ash), water content, etc.

IV. Experimental work

A. Core Cutter

The in situ density of soil is needed for the determination of bearing capacity of soil, for the purpose of stability analysis of slopes, for the determination of pressure on underlying strata for calculation of settlement and design of underground structures. It is very important quality control test, where compaction is required, in the case like embankment, earth dam and pavement construction. On field the moisture content of sand is likely to vary from time to time and hence the field density also. The relationship that can be established between the dry densities with known moisture content is as follows:

$$\gamma d = \frac{\gamma_b}{1 + w}$$

Where, γd = Dry density,
γ_b = Bulk density
w = Water content

Fig. 2: Equipment of Core Cutter

Field Test No.	1
Mass of core cutter (g), W_1	993
Mass of cutter + soil (g), W_2	2958
Mass of moist soil (g), (W_2- W_1)	1965
Average water content, w (%)	16
Field bulk density (g/cm^3), $\gamma_t = \frac{W_2 - W_1}{V}$	1.92
Field dry density (g/cm^3), $\gamma_d = \frac{\gamma_t}{1+w}$	1.66

Table 1: Result of Core Cutter

B. Grain Size Analisys

This test is performed to determine the percentage of different grain sizes contained within a soil. The mechanical or sieve analysis is performed to determine the distribution of the coarser, larger-sized particles. The distribution of different grain sizes affects the engineering properties of soil. Grain size analysis provides the grain size distribution, and it is required in classifying the soil.

Fig. 3: Equipment of Grain Size Analysis

Sieve size (mm)	Mass of soil retained (g)	Percentage retained (%)	Cumulative percent retained (%)	Percent. Finer (%)
4.75	2.4	10.9	10.9	89.1
2.36	4.4	20	30.9	69.1
1.18	5	22.72	53.36	46.64
600(micron)	2	9.09	62.71	37.29
300	2.5	11.36	74.07	25.93
150	4.2	19.09	93.16	6.84
75	1.2	5.45	98.61	1.39
Pan	0.3	1.36	100 %	0.0
Total	22 gm.	100 %	-	-

Table 2: Result of Grain Size Analysis

C. Standard Proctor Test

In the Standard Proctor Test, the soil is compacted by a 5.5 lb hammer falling a distance of one foot into a soil filled mold. The mold is filled with three equal layers of soil, and each layer is subjected to 25 drops of the hammer. Mechanical compaction is one of the most common and cost effective means of stabilizing soils. Design specifications usually state the required density and the water content. In general, most engineering properties, such as the strength, stiffness, resistance to shrinkage, and imperviousness of the soil, will improve by increasing the soil density. The optimum water content is the water content that results in the greatest density for a specified compactive effort. Compacting at water contents higher than (wet of) the optimum water content results in a relatively dispersed soil structure (parallel particle orientations) that is weaker, more ductile, less pervious, softer, more susceptible to shrinking, and less susceptible to swelling than soil compacted dry of optimum to the same density. The soil compacted lower than (dry of) the optimum water content typically results in a flocculated soil structure (random particle orientations) that has the opposite characteristics of the soil compacted wet of the optimum water content to the same density.

Fig. 4: Equipment of Standard Proctor Test

Test No.	1	2	3	4
Mass of mould+ compacted soil (g)	6946.80	7079.34	7278.14	7267.10

Mass of compacted soil ,Wt (g)	3909.80	4042.34	4241.14	4230.10
Bulk density ,	1.77	1.83	1.92	1.915
Average water content, w (%)	8%	11%	14%	17%
Dry density , (g/cc)	1.63	1.65	1.68	1.64

Table 2: Result on Standard Proctor

D. Unconfined Compression Test

The unconfined compressive strength (qu) is defined as the compressive stress at which an unconfined cylindrical specimen of soil will fail in a simple compression test. In addition, in this test method, the unconfined compressive strength is taken as the maximum load attained per unit area, or the load per unit area at 15% axial strain, whichever occurs first during the performance of a test.

For soils, the undrained shear strength (su) is necessary for the determination of the bearing capacity of foundations, dams, etc. The undrained shear strength (su) of clays is commonly determined from an unconfined compression test. The undrained shear strength (su) of a cohesive soil is equal to one-half the unconfined compressive strength (qu) when the soil is under the f = 0 condition (f = the angle of internal friction). The most critical condition for the soil usually occurs immediately after construction, which represents undrained conditions, when the undrained shear strength is basically equal to the cohesion(c). This is expressed as:

$$Su = C = \frac{q_u}{2}$$

Then, as time passes, the pore water in the soil slowly dissipates, and the intergranular stress increases, so that the drained shear strength (s), given by s = c+ s'tan f, must be used.

Fig. 4: Equipment of Unconfined Compressive test

Vertical deformation (ΔL)		Compressive load		Vertical Strain $\xi = \frac{\Delta L}{L_0}$	Corrected area (mm^2) $A = \frac{A_0}{1-\xi}$	Unconfined Compressive stress (N/mm^2)	Unconfined Compressive stress (kN/m^2)
(div.)	(mm)	(div.)	(kg)				
50	0.5	9	3.6	0.0065	1140.95	0.031	31
100	1	16	6.4	0.013	1148.47	0.055	55
150	1.5	24	9.6	0.019	1155.49	0.083	83
200	2	28	11.2	0.026	1163.79	0.096	96
250	2.5	31	12.4	0.032	1171.01	0.105	105
300	3	32	12.8	0.039	1179.54	0.108	108
350	3.5	34	13.6	0.046	1188.19	0.114	114
400	4	34	13.6	0.052	1187.20	0.114	114
450	4.5	34	13.6	0.059	1204.61	0.112	112
500	5	33	13.2	0.065	1212.34	0.108	108
550	5.5	32	12.8	0.072	1221.48	0.104	104

Table 4: Result of Unconfined Compressive Test

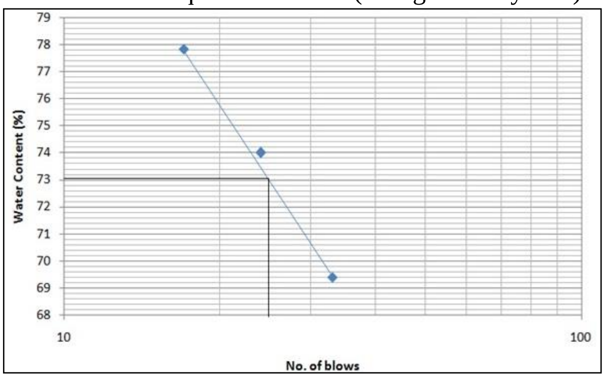
V. LABORATORY TEST ON NATURAL SOIL+DIFFERENT PERCENTAGE OF FLY ASH

Test No.	1	2	3
No. of blows	18	25	34
Mass of can (g)	4.1	15.9	15.6
Mass of can + wet soil, (g)	36.5	36.9	35.1
Mass of can + dry soil, (g)	27.5	28	27.1
Mass of water (g)	9	8.9	8
Mass of dry soil (g)	11.4	12.1	11.5
Water content (%)	78.94	74	69.5

Table 5.1 a: Liquid Limit Test (Using 15% Fly Ash)

Test No.	1	2	3
No. of blows	17	24	33
Mass of can (g)	16.1	15.9	15.9
Mass of can + wet soil, (g)	37.5	36.9	36.4
Mass of can + dry soil, (g)	28.2	28	28
Mass of water (g)	9.3	8.9	8.4
Mass of dry soil (g)	12.1	12.1	12.1
Water content (%)	77.85	74	69.4

Table 5.1 b: Liquid Limit Test (Using 20% Fly Ash)



Test No.	1	2	3
Mass of can (g)	15.5	13.3	10.3
Mass of can + wet soil, (g)	32.6	30.3	28.5
Mass of can + dry soil, (g)	28	26	25
Mass of water (g)	4.6	4.3	3.5

Mass of dry soil (g)	12.5	12.7	14.7
Water content (%)	36.8	33.85	24

Table 5.1 d: Pastic Limit Test (Using 15% Fly Ash)

	1	2	3
Mass of can (g)	13.4	15.5	15.2
Mass of can + wet soil, (g)	30.1	32.6	33.6
Mass of can + dry soil, (g)	26.18	28	30.3
Mass of water (g)	4	4.6	4.5
Mass of dry soil (g)	12.7	12.5	15.1
Water content (%)	31.49	36.8	29.8

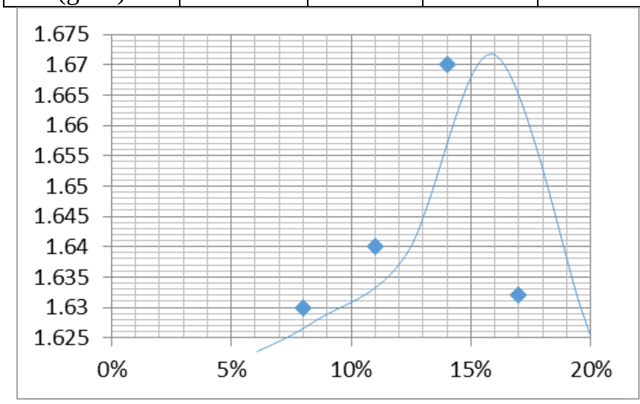
Table 5.1 e: Pastic Limit Test (Using 15% Fly Ash)

A. *Plasticity Index*

% of Fly Ash	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index
15% fly ash	74	32.69	41.31
20% fly ash	73.2	31.55	41.65

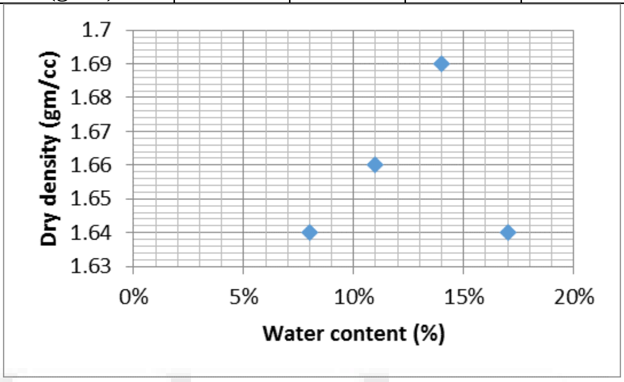
B. *Proctor Compaction Test (Using 15% Fly Ash)*

Test No.	1	2	3	4
Mass of mould+ compacted soil (g)	6949.015	7061.67	7267.10	7256.05
Mass of compacted soil ,Wt (g)	3912.015	4024.67	4230.10	4219.05
Bulk density , $\gamma_t = \frac{W_t}{V}$	1.771	1.822	1.915	1.910
Average water content, w(%)	8%	11%	14%	17%
Dry density , $\gamma_d = \frac{\gamma_t}{1+w}$ (g/cc)	1.63	1.64	1.67	1.632



C. *Proctor Compaction Test (Using 20% Fly Ash)*

Test No.	1	2	3	4
Mass of mould+ compacted soil (g)	6988.77	7169.90	7346.62	7333.36
Mass of compacted soil ,Wt (g)	3951.77	4132.90	4309.62	4296.36
Bulk density , $\gamma_t = \frac{W_t}{V}$	1.789	1.871	1.951	1.945
Average water content, w (%)	8%	11%	14%	17%
Dry density , $\gamma_d = \frac{\gamma_t}{1+w}$ (g/cc)	1.66	1.69	1.71	1.66



D. *Unconfined Compression Test (Using 15% Fly Ash)*

Vertical deformation (ΔL)		Compressive load		Vertical Strain $\xi = \frac{\Delta L}{L_0}$	Corrected area $A = \frac{A_0}{1-\xi}$ (mm^2)	Unconfined Compressive stress (N/mm^2)	Unconfined Compressive stress (kN/m^2)
(div.)	(mm)	(div.)	(kg)				
50	0.5	8	3.2	0.0065	1140.95	0.028	28
100	1	17	6.8	0.013	1148.47	0.059	59
150	1.5	23	9.2	0.019	1155.49	0.079	79
200	2	28	11.2	0.026	1163.79	0.096	96
250	2.5	31	12.4	0.032	1171.01	0.105	105
300	3	33	13.2	0.039	1179.54	0.111	111
350	3.5	35	14	0.046	1188.19	0.117	117
400	4	35	14	0.052	1187.20	0.121	121
450	4.5	36	14.4	0.059	1204.61	0.119	119
500	5	36	14.4	0.065	1212.34	0.122	122
550	5.5	37	14.8	0.072	1221.48	0.117	117

600	6	37	14.8	0.078	1229.43	0.120	120
650	6.5	36	14.4	0.085	1238.84	0.116	116

E. Unconfined Compression Test (Using 20% Fly AshVI VI Result Analysis

Vertical deformation (ΔL)		Compressive load		Vertical $\xi=\frac{\Delta L}{L_0}$ Strain	Corrected area $\frac{A_0}{1-\xi}=A$ (mm^2)	Unconfined Compressive stress (N/mm^2)	Unconfined Compressive stress (kN/m^2)
(div.)	(mm)	(div.)	(kg)				
50	0.5	9	3.6	0.0065	1140.95	0.0315	31.5
100	1	16	6.4	0.013	1148.47	0.055	55
150	1.5	24	9.6	0.019	1155.49	0.083	83
200	2	29	11.6	0.026	1163.79	0.099	99
250	2.5	30	12	0.032	1171.01	0.102	102
300	3	32	12.8	0.039	1179.54	0.108	108
350	3.5	34	13.6	0.046	1188.19	0.114	114
400	4	35	14	0.052	1187.20	0.117	117
450	4.5	36	14.4	0.059	1204.61	0.119	119
500	5	36	14.4	0.065	1212.34	0.118	118
550	5.5	37	14.8	0.072	1221.48	0.121	121
600	6	38	15.2	0.078	1229.43	0.123	123
650	6.5	38	15.2	0.085	1238.84	0.122	122
700	7	37	14.8	0.092	1248.39	0.118	118

VI. RESULT ANALYSIS

A. Test Results of Natural Soil

TEST	PROPERTES		
Core Cutter	Bulk density	Dry density	-
	1.92 gm/cc	1.66 gm/cc	-
Grain size analysis/ Hydrometer test	% Gravel	% Sand	% Fines
	1.11	9.89	89
Atterberg Limit Tests	Liquid Limit	Plastic Limit	Plasticity Index
	74.4%	38.4%	37.6%
ShrinkageLimit	9.22%	-	-
Proctor Compaction Test	OMC	Maximum Dry Density	-
	14%	1.68gm/cc	-
Unconfined Compression Test	114kN/m^2	-	-

B. Results of natural soil + fly ash in different proportion

Tests	Fly ash 15%	Fly ash 20%
Liquid Limit	74	73.2
Plastic Limit	32.69	31.55
Plasticity Index	41.31	41.65
MaximumDry Density(gm/cc)	1.67	1.69
Optimum Moisture Content (%)	14	14
Unconfined Compressive Stress	122	123

VII. CONCLUSION

1) As the locally available borrow soil has generally high plasticity (LL > 50) it is difficult to construct on it
2) The inclusion of different percentage of fly ash in natural soil generally resulted in some increasing in unconfined compressive stress
3) The unconfined compressive stress of natural soil without fly ash which was 114kN/m2,and wasincreased up to123kN/m2on addition of 20% fly ash in natural soil. Itshowed 7.89% improvement.
4) A liquid limit was decreased with increase in percentage of fly ash. This was 74.4%, in natural soil and decreased to 72.5% after the addition of fly ash, showing 2.56 % decreased.
5) Plastic limit was decreased with increasein percentage of fly ash.This was38.4%in natural soil and decreased to 32.93 %after adding fly ashshowing 14.24 % decrement.
6) Maximum dry density was increased with increase in percentage of fly ash.This was1.68gm/ccin natural soiland increasedto 1.71gm/ccat 14% OMC showing 1.78 % increment.
7) As per grain size analysis the percentage of gravel is1.11%, percentage of sand is9.89% and percentage of fines is 89%.in the soil sample.
8) It can be concluded that addition of fly ash shows very minor difference in the properties of soil, so for good results fly ash may not be used as stabilizer and we should go for other material.

REFERENCES

[1] Berawala K. S. and Solanki C. H., 2010; "Empirical Correlations of Expansive Soils Parameters for the Surat Region", Indian Geotechnical Conference
[2] Dr. B.C. PUNAMIA, ARUN KUMAR JAIN &ASHOK KUMAR JAIN "Soil Mechanics and Foundation"
[3] Chee-Ming Chan and Meei-Hoan Ho, 2010; "The Potential of Using Rubberchips as a Soft Clay Stabilizer Enhancing Agent", Postgraduate Incentive Research Grant, Universiti Tun Hussein Onn, Malaysia.

[4] Dr. K.R. ARORA “Soil Mechanics and Foundation Engineering”
[5] Pandian,N.S.,Krishna ,K.C.& Leelavathamma B., (2002), Effect of Fly Ash on the CBR Behaviour of Soils, Indian Geotechnical Conference, Allahabad, Vol.1,pp.183-186.
[6] Phanikumar B.R., & Radhey S.Sharma(2004) “Effect of flyash on Engg properties of Expansive Soil” Journal of Geotechnical and Geoenvironmental Engineering Vol. 130, no 7,July, pp. 764-767.
[7] S. Bhuvaneshwari and R. G. Robinson and S. R. Gandhi, 2005; “Stabilization of expansive soil using flyash”, india, delhi

