Influence of Fly ash – Sand on Engineering Properties of Black Cotton Soil

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Abstract **- Expansive soil is treacherous from civil engineering construction point of view as it is volumetrically unstable due to seasonal moisture variation. Its strength decreases and compressibility increases tremendously on wetting. To counteract the problems of the expansive soil, different innovative foundation techniques and stabilization with various additives have been suggested. Soil improvement using the waste materials like slags, fly ash, rise husk ash etc. in geotechnical engineering has been in practice from environment point of view. With this view point in the present investigation an attempt has been made to study the influence of fly ash – sand on engineering properties of Black Cotton Soil. The study was carried out by proper grading and mixing of black cotton soil – fly ash – sand in specified percentage by weight. Results of the study have been found to be quite encouraging.**

Keywords **—Expansive Soil, Black Cotton Soil, Fly ash, Sand, Engineering Properties**

I. INTRODUCTION

Black Cotton Soil is a term used for Expansive Soil in India, one of the major regional deposits covering about one-fifth of the country's land. The soil extend over the states of Maharashtra, Gujarat, Madhya Pradesh, Andhra Pradesh, Karnataka, Rajasthan, Orissa, Bihar and Uttar Pradesh. The soil exhibit high swelling and shrinkage due to seasonal moisture fluctuations. The type of clay minerals present in black cotton soil are montmorillonite or illite or combination thereof. Expansive soils have susceptibility to undergo volume changes consequent upon changes in moisture content. The alternate swelling and shrinkage has caused a lot of damage to many civil engineering structures. Soil stabilization with additives like lime and calcium chloride have been also tried.

In recent years, huge amount of fly ash generated at thermal power stations and other industrial plants pose a great environmental problem. So, utilization of these wastes would be advantageous way of getting free of them. Utilization of fly ash in the geotechnical sector to improve engineering properties of soil or as an artificial geomaterial is a concept gaining popularity these days. Hence, an attempt has been made to modify the engineering properties of black cotton soil with required quantity of fly ash and sand.

II. ABBREVIATIONS

BCS	Black Cotton Soil
DFS	Differential Free Swell
LL	Liquid Limit
PL	Plastic Limit
MDD	Maximum Dry Density
OMC	Optimum Moisture Content
UCS	Unconfined Compressive Strength

III. MATERIALS

The different materials used in the experimental investigation are Expansive Soil (i.e. Black Cotton Soil), Fly ash and Sand.

Black Cotton Soil : The black cotton soil used in this study was collected from GIDC, Savali Site, Dist. Vadodara. Soil passing through IS-1.18 mm sieve was used. The physical properties of soil sample is given in Table 1.

Fly ash : The stabilization material used in this study was fly ash. Fly ash used in this study collected from Thermal Power Station, Gandhinagar. The physical properties of fly ash are presented in Table 2 and Chemical properties of fly ash are presented in Table 3.

Sand : The sand used for investigation is air dry. The properties of sand used are as given in Table 4. The sand does not contain gravel. Clay and silt fraction are less than 1%.

Table 1 : Physical Properties of Black cotton Soil

Sr. No.	Property	Result
1	Colour	Black
2	Specific Gravity	2.7
3	Liquid Limit (%)	56
4	Plastic Limit (%)	26.2
5	Plasticity Index (%)	29.8
6	Shrinkage Limit (%)	9.8
7	Differential Free Swell (%)	50

Table 2 : Physical Properties of Fly ash

Sr. No.	Property	Result
1	Colour	Grey
2	Nature	Amorphous
3	Specific Surface Area (cm^2/gm)	2800-3200
4	Specific Graviry	2.138
5	Consistency (%)	31.5
6	Liquid Limit (%)	30
7	Plastic Limit (%)	Non Plastic
8	Unconfined Compressive Strength (kg/cm^2)	1.75

Table 3 : Chemical Properties of Fly ash

Sr. No.	Constituents	Result	As per IS 3812 - 1981
1	$SiO_2 + Al_2O_3 + Fe_2O_3$	88 %	70 % Min.
2	SiO_2	57.83 %	35 % Min.
3	Al_2O_3	26.22 %	---
4	Fe_2O_3	6.08 %	---
5	CaO	1.42 %	---
6	MgO	3.10 %	5 % Max.
7	Total Sulphur as SO	---	2.75 % Max.
8	Loss on ignition	1.07 %	12 % Max.

Table 4 : Properties of Sand

Sr. No.	Property	Result
1	Specific Gravity	2.624
2	Minimum Density	1.414 gm/cc
3	Maximum Density	1.767 gm/cc
4	Minimum Void Ratio	0.485
5	Maximum Void Ratio	0.856
6	D_{10} Size	0.355
7	D_{30} Size	0.567
8	D_{60} Size	0.930
9	Uniformity Coefficient (C_U)	2.620
10	Coefficient of Curvature (Cc)	0.974

The experimental study was carried out under controlled conditions to study effect of Black Cotton Soil – Fly ash – Sand on Engineering Properties such as Differential free swell, Plasticity index, Shrinkage limit, Maximum dry density, Optimum moisture content, and Unconfined compressive strength. Fly ash and Sand mixed in varying percentage by weight of dry soil.

The following samples were prepared for experimental work :

$BCSF_1S_2$ – Black Cotton Soil + 10% Fly ash + 20% Sand
$BCSF_1S_4$ – Black Cotton Soil + 10% Fly ash + 40% Sand
$BCSF_1S_5$ – Black Cotton Soil + 10% Fly ash + 50% Sand
$BCSF_2S_2$ – Black Cotton Soil + 20% Fly ash + 20% Sand
$BCSF_2S_4$ – Black Cotton Soil + 20% Fly ash + 40% Sand
$BCSF_2S_5$ – Black Cotton Soil + 20% Fly ash + 50% Sand

IV. RESULTS AND DISCUSSION

Mix	DFS %	LL %	PL %	Plasticity	Shrinkage	MDD	OMC %	UCS

				Index %	Limit %	gm/cm^3		kg/cm^2
BCS	50	56	26.2	29.8	9.8	1.63	20.91	0.727
$BCSF_1S_2$	25	35	18.7	16.3	14.31	1.766	14.91	0.998
$BCSF_1S_4$	20	26	16.1	9.9	13.31	1.845	13.54	0.976
$BCSF_1S_5$	18.2	22.4	14.4	8.0	11.88	1.884	11.52	0.965
$BCSF_2S_2$	18.2	32.9	18.4	14.5	13.9	1.774	14.94	1.147
$BCSF_2S_4$	10	24	15.8	8.2	13.75	1.871	11.63	1.112
$BCSF_2S_5$	0	19	13.7	5.3	12.85	1.885	11.26	1.060

From the above result it can be see that the intimate mixture of Black Cotton Soil – Fly ash – Sand prevents the montmorillonite clay particle from exhibiting high volume change. During saturation heave is prevented as fly ash and sand act as non swelling soils. Fly ash absorb water, so the effect of montmorillonite mineral present in the expansive soil possessing expanding lattice and exhibiting high volume change in presence of water is reduced. In the dry condition fly ash and sand occupy the extra space left by the shrinkage of soil. The geomaterial obtained in this manner is comparatively well graded.

V. CONCLUSION

From the present investigation on the use of fly ash and sand as an admixture to improve the properties of black cotton soil the following conclusions can be drawn.

(1) In comparison to black cotton soil, for black cotton soil – fly ash – sand mix $BCSF_2S_5$ (30:20:50) prepared, the values of differential free swell reduced 50% to zero, plasticity index from 29.8 % to 5.3 %, shrinkage limit increases from 9.8 % to 12.85 %. This indicates increase in the percentage of fly ash and sand contributes to plastic behaviour of soil which reduces susceptibility to undergo volume changes consequent upon change in the moisture content.

(2) In comparison to black cotton soil, for mix $BCSF_2S_5$ the value of OMC reduced 20.91 % to 11.26 % and MDD increased from 1.63 gm/cm^3 to 1.885 gm/cm^3.This shows that black cotton soil treated with fly ash and sand gives the effect of increased compactive effort.

(3) From the above result it can be concluded that black cotton soil treated with 20% fly ash and 50% sand has significant effect on engineering properties of soil. Hence, black cotton soil treated with fly ash and sand may be considered as a viable alteration to improve engineering characteristics and load carrying capacity of expansive soil. This geomaterial can be adopted to improve the stability of structures resting on black cotton soil.

REFERENCES

[1] A. K. Chaudhari " Influence of Fly ash on the Characteristics of Expansive Soil", Proceedings of Indian Geotechnical Conference, 215-218, 1994

[2] B. M. Basavanna, Itagi Ravi Kumar, " Use of Coal ash to improve some properties of black cotton soil", Proceedings of Indian Geotechnical Conference, 215-218, 1990

[3] B. R. Phanikumar, V. Ramesh, M.V.B. ramasastry " Efficacy of Calcium Chloride in Stabilizing Swelling Soils", Proceedings of Indian Geotechnical Conference, 245-246, 1998

[4] M. M. Savarkundlawala (2004) " Influence of Fly ash - Sand on Engineering Characteristics of Expansive Soil" M.E. Thesis submitted to M. S. University of Baroda, Vadodara, India.

[5] Behaviour of Standard Expansive Soil and Control methods by Prof. (Dr.) R. K. Katti

[6] Basic Principles of Geotechnical Engineering by Braja M. Das

[7] Indian Standard – IS : 3812:1981 Specification of Fly ash – for use as Pozzolona

[8] Indian Standard – IS : 2720:1973 Methods of test for soils : Part 3 : 1980 (Section I) Determination of Specific Gravity (First Revision)

[9] Indian Standard – IS : 2720:1977 Methods of test for soils : Part (XL) : Determination of Free Swell of Soil

[10] Indian Standard – IS : 2720:1985 Methods of test for soils : Part 5 : Determination of Liquid Limit and Plastic Limit (Second Revision)

[11] Indian Standard – IS : 2720:1980 Methods of test for soils : Part 7 : Determination of Water Content – Dry Density using light compaction (Second Revision)

[12] Indian Standard – IS : 2720:1964 Methods of test for soils : Part 6 : Determination of Shrinkage factors

[13] Indian Standard – IS : 2720:1964 Methods of test for soils : Part 10 : Determination of Unconfined Compressive Strength