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Stabilization of Black Cotton Soil by Using Fly Ash Powder

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ABSTRACT

Nearly 51.8 million hectares of land area in India are covered with black cotton soil. The property of these soils, in general, is that they are very hard when in dry state, but they lose all of their strength when in wet state. In light of this property of black cotton soil, these soils pose problems worldwide that serve as challenge to overcome for the Geotechnical engineers. One of the most important aspects for construction purposes is soil stabilization, which is used widely in foundation and road pavement constructions; this is because such a stabilization regime improves engineering properties of the soil, such as volume stability, strength and durability. In this process, removal or replacing of the problematic soil is done; replacement is done by a better quality material, or the soil is treated with an additive. In the present study, using fly ash obtained from Balapur, stabilization of black cotton soil is attempted. With various proportions of this Additive i.e. 5%, 10%, 15%, 20%, expansive soils is stabilized. Owing to the fact that fly ash possess no plastic property, plasticity index (P.I.) of fly ash mixes show a decrease in value with increasing fly ash content. In conclusion, addition of fly ash results in decrease in plasticity of the expansive soil, and increase in workability by changing its grain size and colloidal reaction. Tested under the CBR values of clay with fly ash mixes were observed. Analysis of the formerly found result exposes the potential of fly ash as an additive that could be used for improving the engineering properties of black cotton soils.

Keywords- Black Cotton Soil, Fly Ash, Material, Soil Stabilization.

1. INTRODUCTION

India has 51.8 million hectares land region that is included with black cotton soil. Various techniques are adopted to enhance the engineering belongings of black cotton soil. Over the past few periods several factors have led to an increase in the number of people migrating to large cities. Consequently these large cities are getting over populated and quite expectedly necessity of business, residential construction has increased the civil engineering projects located in areas with unsuitable soil is one of the most common problems in many parts of the world. Black cotton Soil can be replaced with stronger material by usual method of soil stabilization.

Main objective of our research is to stabilize the locally available black cotton soil near Akola city. The stabilization is done for the following reasons.

Soil stabilization is widely used in connection with road, pavement and foundation construction.

It improves the engineering properties of the soil, e.g.:

a) Strength - to increase the strength and bearing capacity,
b) Volume stability - to control the swell-shrink characteristics caused by moisture changes,
c) Durability - to increase the resistance to erosion, weathering or traffic loading.
d) To reduce the pavement thickness as well as cost.

2. SOIL STABILIZATION.

Soil stabilization is a general term for any physical, chemical, biological or combined method of changing a natural soil to meet an engineering purpose. Improvements include increasing the weight bearing capabilities & performance of in-situ subsoil, sands & other waste materials in order to strength.

2.1 Methods of Soil Stabilizations:-
There will be four methods of soil stabilization are as follows:
A. MECHANICAL STABILIZATION
B. PHYSICAL STABILIZATION
C. CHEMICAL STABILIZATION
D. PHYSIO CHEMICAL STABILIZATION

2.2 Benefits of Soil:-
a) Improve the mechanical qualities of local road construction soil.
b) Increase loading capacity.
c) Improve structural integrity.
d) Reduce harmful moisture penetration.
e) Provide longer economic life of road bed.
f) Reduce maintenance costs.
g) Lower road constructions costs.

2.3 Soil Properties:-
Some of the important properties of soils that are used by geotechnical engineers to analyze site conditions & design earthworks, retaining structures, & foundation are-
a) Specific weight or Unit weight.
b) Porosity.
c) Void ratio.
d) Permeability.
e) Compressibility.
f) Shear Strength.
g) Atterbegs Limits.

3. MATERIAL

3.1 Black Cotton Soils:-
As a part of this investigation, the expansive black cotton soil was acquired from the site Vyala, Maharashtra. The black cotton soil thus obtained was carried to the laboratory in sacks. A small amount of soil was taken, sieved through 400 mm sieve, weighed, and air-dried before weighing again to determine the natural moisture content of the same. The various geotechnical properties of the procured soil are as follows:

Table 1: Standard Properties of black cotton soil

Sr. No.	Properties	Code referred	Value
1	Specific Gravity	IS 2720 (Part 3/Sec 1) – 1980	2.44
2	Maximum Dry Density (MDD)	IS 2720 (Part 7) – 1980	1.52 gm/cc
3	Optimum Moisture Content (OMC)	IS 2720 (Part 7) – 1980	22.65%
4	Natural Moisture Content	IS 2720 (Part 2) – 1973	7.28%
5	Free Swell Index	IS 2720 (Part 40) – 1977	105%
6	Liquid Limit	IS 2720 (Part 5) – 1985	65%
7	Plastic Limit	IS 2720 (Part 5) – 1985	37.08%
8	Shrinkage Limit	IS 2720 (Part 6) - 1972	17.37%

3.2 Fly Ash:
A waste material extracted from the gases emanating from coal fired furnaces, generally of a thermal power plant, is called fly ash. The mineral residue that is left behind after the burning of coal is the fly ash. The Electro Static Precipitator (ESP) of the power plants collects these fly ashes. Essentially consisting of alumina, silica and iron, fly ashes are micro-sized particles. Fly ash particles are generally spherical in size, and this property makes it easy for them to blend and flow, to make a suitable concoction. Both amorphous and crystalline nature of minerals is the content of fly ash generated. Its content varies with the change in nature of the coal used for the burning process, but it basically is a non-plastic silt. For the purpose of investigations in this study, fly ash was obtained from SesaSterlite, Jharsuguda. To separate out the vegetation and foreign material, this fly ash was screen through a 2 mm sieve. The samples were dried in the oven for about 24 hours before further usage.

Table 2: Properties of fly ash.

Properties	Range
Color	Grey
Sp. Gravity	1.95-2.55
Plasticity	Non-plastic
O.M.C (%)	38.0-18.0
M.D.D(gm/cc)	0.9-1.6

3.3 Classification of fly ash:

The extracted ash from the flue gases via an Electro Static Precipitator, after the process of pulverization, is called fly ash. It is the finest of particles among bottom ash, pond ash and fly ash. With some unburned carbon, the fly ash chiefly consists of non-combustible particulate matter. These generally consists of silt-sized particles. On the basis of a lime reactivity test, fly ashes have been classified into four different types, as given:

a) Cementations fly ash
b) Cementations and pozzolanic fly ash
c) Pozzolanic fly ash
d) Non-pozzolanic fly ash

With free lime content and negligible reactive silica, this fly ash is called as cementations. As opposed to this, with negligible free lime content, and chiefly reactive silica, this fly ash is called pozzolanic fly ash. Both reactive silica and free lime are predominant in cementations and pozzolanic fly ash. Neither free lime, nor reactive silica are present in non-pozzolanic fly ash. The distinguishable difference between cementations fly ash and pozzolanic fly ash is that the cementations fly ash hardens when it comes in connation with water, whereas the pozzolanic fly ash hardens only after the activated lime reacts with water. Cementations & Pozzolanic Fly Ash and Pozzolanic Fly Ash are the types that are found widely. Based on the chemical composition of fly ash, fly ash has been categorized into two categories, as given:

A. Class C fly ash
B. Class F fly ash

Burning of sub-bituminous type of coal and lignite, which contains more than 20% Calcium

Oxide, gives the Class C fly ash. By ignition of anthracite and bituminous type of coal, Class F fly ash. This fly ash contains less than 20% Calcium Oxide.

4. METHODOLOGY

The Indian Standard codes are as follows:

1) Oven drying method – fly ash mixture
2) Atterbegs Limit- fly ash mixture
3) Specific gravity method- fly ash mixture
4) Standard Proctor test- fly ash mixture
5) California bearing ratio- fly ash mixture
6) Unconfined compressive strength- fly ash mixture

4.1 Oven drying method – fly ash mixture

Description**:** Water content of soil is an important parameter which influences the behavior, particularly of cohesive soils.

Table 3: Results observed for oven drying method

% Of Fly Ash	**W.C**
0	42.88
5	40.22
10	31.35
15	23.65

4.2 Atterbegs Limit- fly ash mixture

1) Liquid limit: - (Casagrande's Method IS 2720-PART5)

Description:-

This method uses the Casagrande's liquid limit apparatus consisting of a metal dish or cup mounted on a hard rubber pad, fixed with a cam mechanism.

2) Plastic limit

Description:-

It is the minimum water content at which a soil will just begin to crumble when rolled into 3 mm thread without showing any sign of cracks.

Table 4: Atterbegs Limit of the Soil

Soil Type	Liquid Limit (%)	Plastic Limit (%)	Plasticity index (%)
0	83.27	29.76	53.51
5	66.19	26.24	39.95
10	66.02	23.96	42.06
15	60.65	10.86	49.76
20	59.91	18.55	41.36

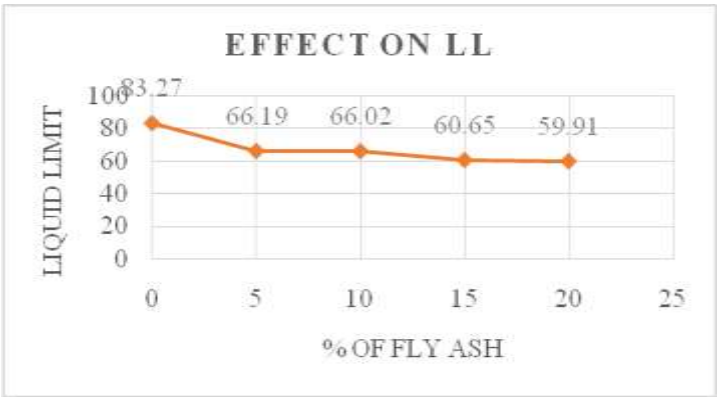

Fig 1: Liquid limit distribution curve for fly ash

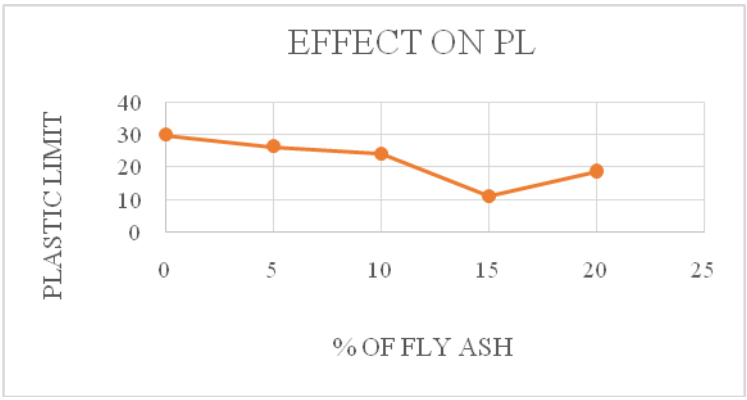

Fig 2: Plastic limit distribution curve for fly ash

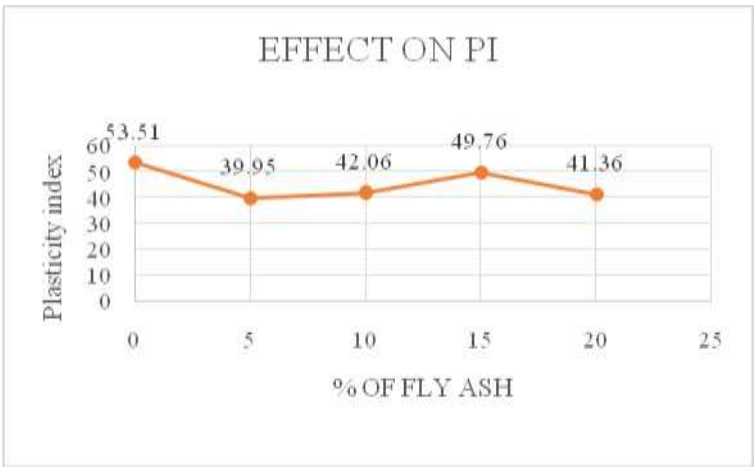

Fig 3: Plasticity index distribution curve for fly ash

4.3 Specific gravity method- fly ash mixture

Specific Gravity (G) Using Pychometer:-

Description:-Pycnometer is a large size density bottle of about 900 ml capacity.

A conical brass cap 6 mm diameter hole at its top is screwed to open end of pychometer.

Table 5: Specific gravity values for fly ash

% Of Fly Ash	WC
0	2.6
5	2.5
10	2.7
15	2.6
20	2.65

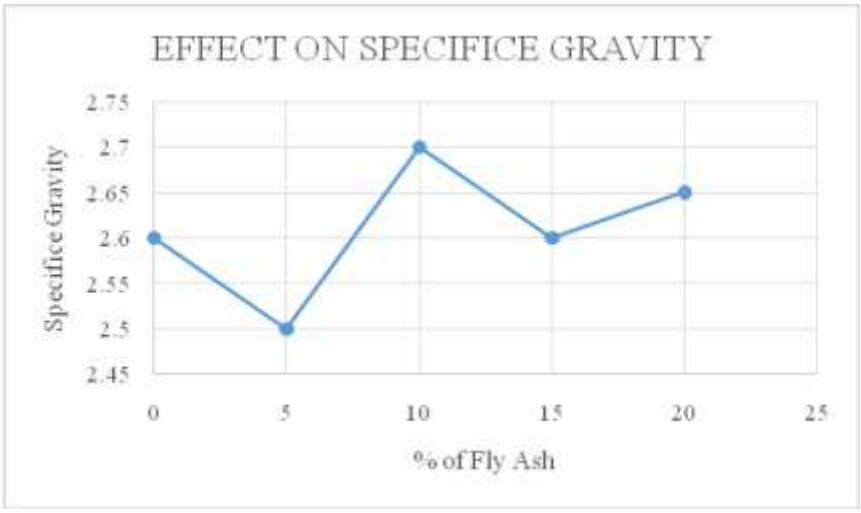

Fig 4. Specific gravity curve for soil with fly ash

4.4 Standard Proctor test- fly ash mixture

Description:- This test was first devised by R. Proctor and has been adopted by ASTM and BSS, as the standard test. The compaction of soil is measured in the term of dry density. The number of laboratory test has been developed for compacting the soil.

The OMC of the soil with varying percentage of Fly Ash is given in table 3 and fig 3

Table 6: OMC values for fly ash

% Of Fly Ash	O.M.C (%)
0	9
5	9.1
10	8.3
15	10.3
20	9.4

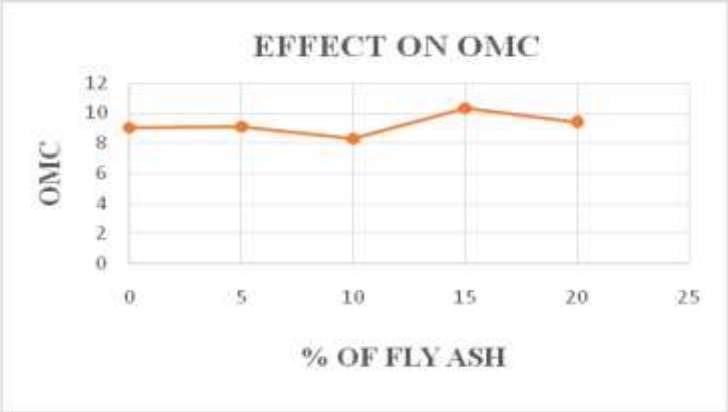

Fig5: OMC curve for fly ash

4.4.1 Maximum dry density

The maximum dry density of the soil with varying percentage of Fly Ash is given in table 4 and fig 4

Table 9: Maximum dry density values for fly ash

% Of Fly Ash	M.D.D
0	2.21
5	2.09
10	2.42
15	2.45
20	2.31

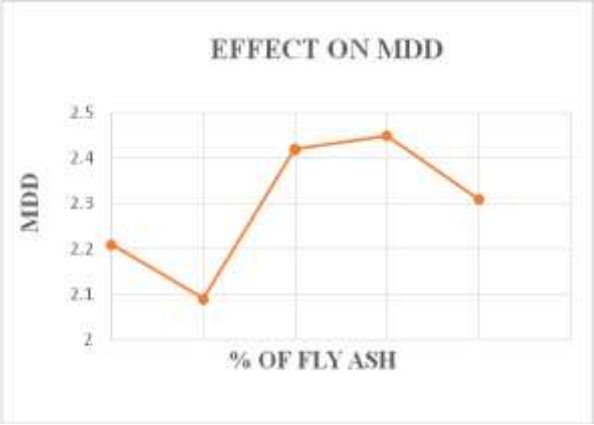

Fig 6: MDD curve for fly ash

4.5 California bearing ratio- fly ash mixture

Description:- The california bearing ratio test is penetration test meant for the evaluation of subgrade strength of roads and pavements. The results obtained by these tests are used with the empirical curves to determine the thickness of pavement and its component layers. This is the most widely used method for the design of flexible pavement.

Table 7 CBR VALUES at 2.5mm deflection

% of Fly Ash	CBR VALUE@ 2.5mm
0	3.02
5	1.67
10	1.61
15	3.85
20	2.23

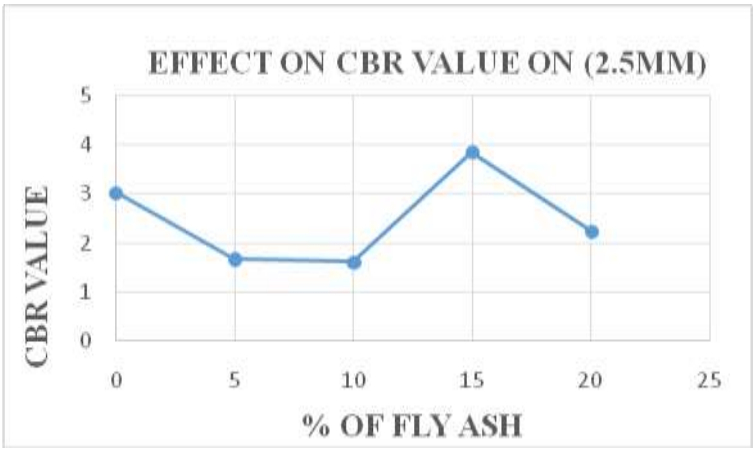

Fig 6 CBR curve for fly ash

Table 8: CBR VALUES at 5mm deflection

% Of Fly Ash	CBR VALUE@ 5mm
0	4.2
5	3.9
10	4.12
15	5.1
20	4.02

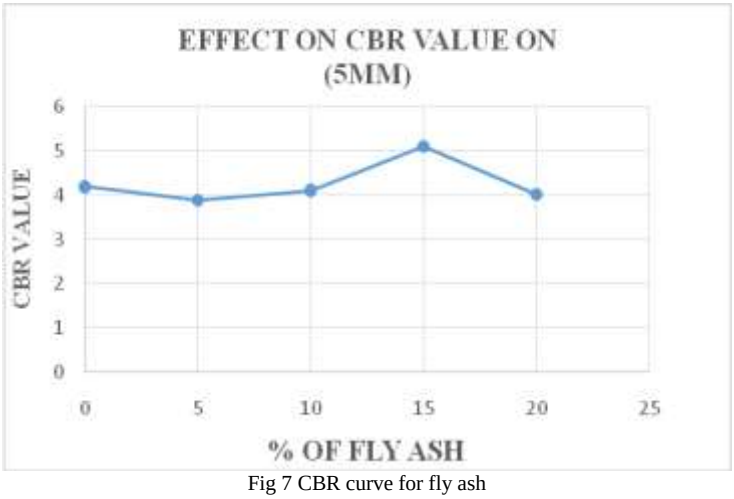

Fig 7 CBR curve for fly ash

4.6 Unconfined compressive strength- fly ash mixture

Table9: UCC values for fly ash

% Of Fly Ash	U.C.C
0	3.88184
5	4.100000
10	4.440923
15	8.881850
20	4.885015

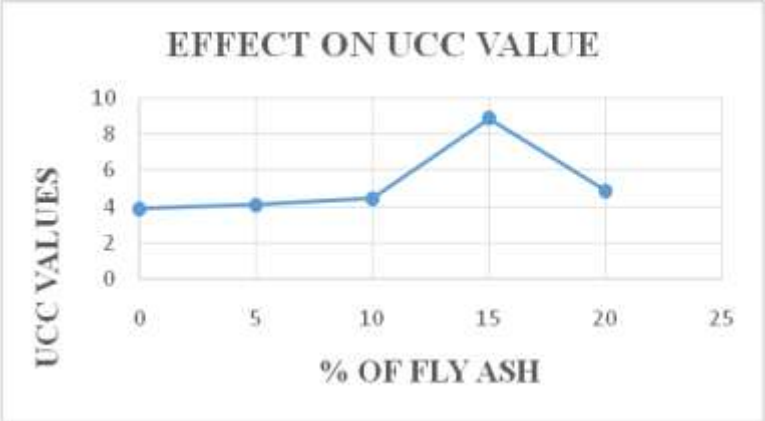

Fig 8. UCC curve for fly ash

5. UTILIZATION OF FLY ASH

The utilization of fly ash can be largely grouped into following three classes:

a) The Low Value Utilizations, which includes back filling, structural fills, road construction, soil stabilization, and embankment & dam construction, ash dykes, etc.
b) The Medium Value Utilizations, which includes grouting, cellular cement, pozzolana cement, bricks/blocks, soil amendment agents, prefabricated building blocks, fly ash concrete, weight aggregate, etc.
c) The High Value Utilizations, which includes, fly ash paints, ceramic industry, extraction of magnetite, distempers, metal recovery, acid refractory bricks, floor and wall tiles, etc.

6. CONCLUSIONS

1) On the basis of the use of Fly Ash on black cotton soil, it shows an effective use.
2) Fly Ash can be used as an additive for the stabilization of soil. In geotechnical engineering applications, fly ash may be feasible.
3) With the increasing fly ash content in the soil-fly ash mixture, the decrease in value of free swell ratio was remarked. This decrease was also reciprocated by the plasticity index values. Plasticity index values are directly proportional to percent swell in an expansive soil, thus affecting the swelling behavior of the soil-fly ash mixture.
4) Fly ash as an additive decreases the swelling, and increases the strength of the black cotton soil.
5) Now it can be concluded that the improved C.B.R. value is due to addition of Fly Ash as admixture to the black cotton soil. Hydraulic conductivity of black cotton soil is also reduced by this method.
6) If black cotton soil is used in road construction then there will be no need of drainage layer after treatment of black cotton soil as sub grade with fly ash.
7) Stabilization by black cotton soil is more economical than any other additives.

7. REFERRNCE

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